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for December, 1936

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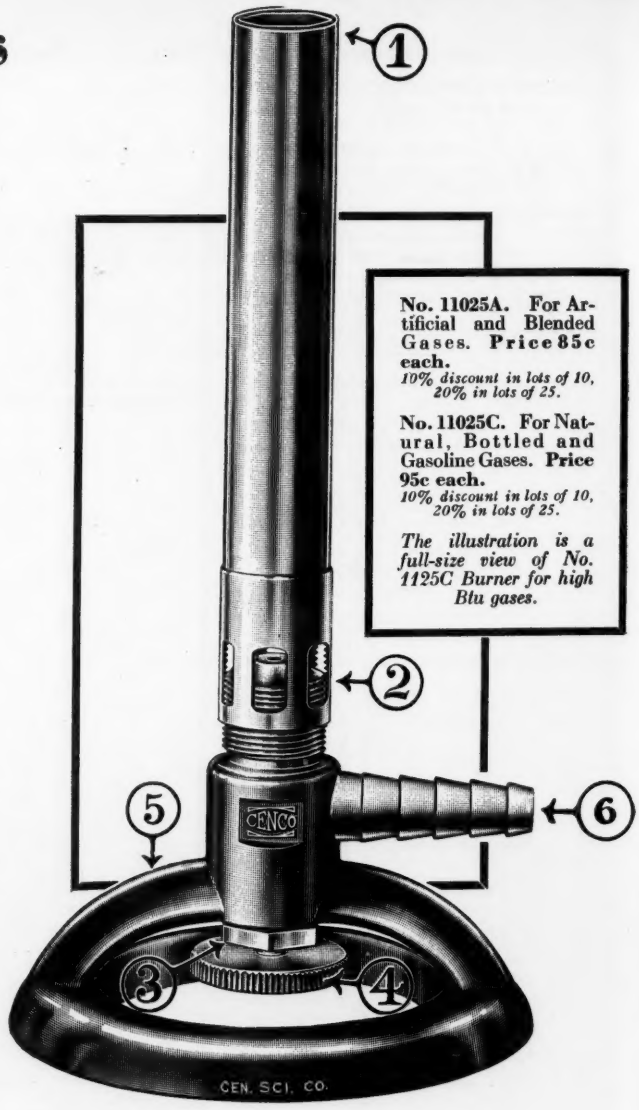

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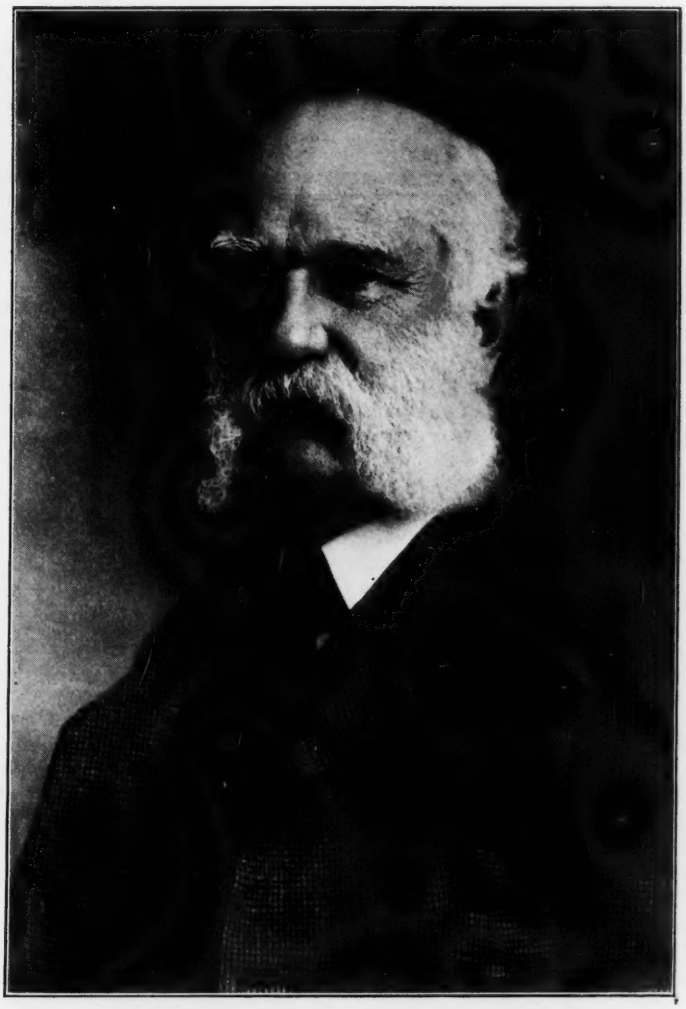

JAMES MASON CRAFTS (1839–1917)

Best known as co-discoverer of the Friedel-Crafts reaction. He was born in Boston and graduated from the Lawrence Scientific School of Harvard University in 1858. Afterward he studied with Plattner at Freiberg, with Bunsen at Heidelberg, and then for four years with Wurtz at Paris. He served for a year as inspector of mines in Mexico. He was the first Professor of Chemistry, 1867–1870, at the newly-established Cornell University, and in 1870 succeeded Storer as Professor of General and Analytical Chemistry at the Massachusetts Institute of Technology. He returned to Paris in 1874 and remained there for seventeen years, doing most of his research in collaboration with Friedel, but some of it independently or with other co-workers. In 1891 Crafts returned to Boston, where he spent the rest of his life. He was professor of Organic Chemistry at the Massachusetts Institute of Technology from 1892 to 1897, and President of the Institute from 1897 to 1900. After resigning the presidency, he continued to work in his laboratory at the Institute and made further contributions to thermometry and to the study of hydrocarbons and of catalysis in solution.

(Contributed by Tenney L. Davis.)

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EDITOR'S OUTLOOK

THE LABORATORY PROBLEM. In a modest little note on page 565 Mr. W. P. Cortelyou makes a contribution toward the solution of two perennial and more or less interrelated problems—the problem of what to do with the superior student, and the problem of injecting at least some semblance of reality into instructional laboratory work.

In real life the laboratory is the place where we seek answers to questions. Too often the student enters the laboratory with no questions in his mind. At best he often seeks there answers to highly artificial questions —answers to which the laboratory is not the unique and inevitable avenue of approach. In the nature of things this can hardly be avoided altogether. It has even been argued that so long as the question is real to the student it fulfills its educational purpose and need cause the instructor no further concern.

While we recognize the expediency of the synthetic laboratory problem, and concede that the better examples have pedagogical value, we have never been able to regard it as thoroughly satisfactory from a philosophical standpoint. Franklin K. Young has been quoted as counseling the young chess student not to give his opponent the benefit of his own skill and insight. In effect, the learner is advised not to reject an attractive move merely because he himself can see a possible refutation of it. This is a bit of advice that we have always instinctively disliked, to say nothing of the fact that a beginner must be an optimistic egotist indeed to suppose that he can see weaknesses in a move which will not also be obvious to his opponent. It is true that a skillful and experienced player may win games from an inferior through unsound lines of play, merely because such lines of play often afford the unwary opponent numerous opportunities for error, and therefore for defeating himself. Such games, however, are not things of chess beauty, and no true chess-lover can take any genuine pride and satisfaction in victories so won. Just so, the true teacher must always feel some dissatisfaction at sending a student into the laboratory to find out what he himself could tell him if he would, or what the student could find out more quickly and at less expense in the library—even though some good may come of it.

As regards the brighter student there is also the drawback that he is quick to recognize and resent such academic boondoggling. One can hardly blame him for playing contemptuously and half-heartedly the old army game of digging a north-and-south trench on Wednesday, and turning it around to run east and west on Thursday.

Therefore, one orchid for Mr. Cortelyou.

OPALS

JOSEPH W. HOWARD

Montana State University, Missoula, Montana

Opal is an amorphous gem stone of the formula $SiO_2 \cdot nH_2O$. *It occurs in a wide variety of colors. The best opals come from Australia, Mexico, Czechoslovakia, and Nevada. Opal is used chiefly as a gem stone.*

✦ ✦ ✦ ✦ ✦ ✦

INTRODUCTION

"OF ALL precious stones," Pliny tells us, "the opal is the most difficult to describe, since it combines the beauties of the many." A later writer (*1*) had much the same idea when he said, "The opal is a precious stone which has in it the bright fiery flame of the carbuncle, the fine refulgent purple of the amethyst, and a whole sea of the emerald's green glory—." To which Albert Ramsay (*2*) has added, "It has everything, the red of rubies, the blue of sapphires. I swear you can get drunk on the color in a good one."

American Museum of Natural History, N. Y.

A CAMEO HEAD CARVED FROM AUSTRALIAN OPAL

And yet with all this beauty the opal has had its ups and downs in popular favor. Empress Eugénie would never wear one because she believed it would bring her ill luck. Queen Victoria, on the other hand, greatly admired the stone and gave each of her daughters a parure of opals and diamonds.

Senator Nonius, during the reign of Julius Caesar, possessed a ring with an opal setting, which Mark Anthony coveted as a gift for Cleopatra. When he objected to parting with it he was told to choose between the jewel and Rome. He decided in favor of his opal.

American Museum of Natural History, N. Y.

CARVED AUSTRALIAN OPAL FROM WHITE CLIFFS, N. S. W.

The opal market was depressed for several years following the publication of Sir Walter Scott's book, "Anne of Geierstein," in which the baleful influence of an opal plays a prominent part.

The name itself originated from the Latin *opalus* or Sanskrit *upalas* (*3*) meaning a stone. The Romans also called the opal *paederos*, the Greek designation for Cupid. Many descriptive names have been applied to individual opals, such as "the burning of Troy," "the volcano," "the flaming forest," "the rainbow," and "the royal peacock."

MODE OF OCCURRENCE

Opal is found as a secondary deposit in the fissures and cavities of many rocks. Like flint, it is often embedded in limestone or clay. In all these locations it appears in compact and irregular masses. Much opal is also found in petrified wood and fossil remains where it has wholly or partially taken the form of the material replaced. One of the most interesting specimens of this kind is the so-called "Crocodile of Lightning

Courtesy Percy Train, M.E., Denio, Oregon

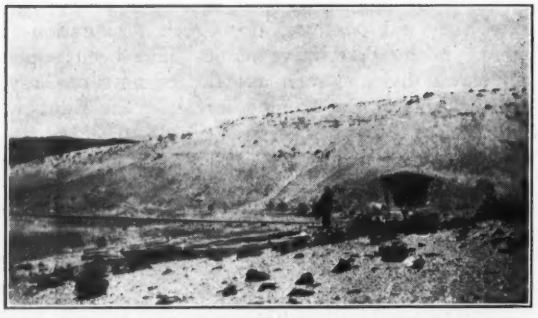
RE-SORTING THE OPAL MATRIX FROM THE RAINBOW RIDGE MINE IN NEVADA

Ridge"—a crocodile's partially opalized jaw and teeth found in one of the Australian mines. Some occurs native in botryoidal and stalactite forms.

SOURCES

For many centuries the world's best opals came from a mine near Czerwenica, Hungary, now in Czechoslovakia (*4*). While they were often marketed as the product of other countries, this mine is considered their real source. Some good opals have been found in Honduras, but Australia (*5*, *6*) and Mexico (*7*) are now the chief foreign producers. Nevada (*8*), Washington (*9*), North Carolina (*10*), Oregon, Idaho, California, Texas, and New Mexico (*4*) have all reported deposits. They are also found in Montana.

The Australian opals are mined at Coober Pedy in South Australia and at White Cliffs and Lightning Ridge in New South Wales. Lightning Ridge is famous as a producer of the highly esteemed black opal. In the words of Charles Henry (*11*), "When you gaze enthralled at the magic colors of the opal that blaze and dance in its mysterious heart, when you thrill to the flash of fire, of crimson deep as blood and blues and greens more vivid than the peacock's tail, think of a drab and lonely sandstone ridge far out on the northern plains of New South Wales." Here, the prospector digs down through the crust of the ridge, locally known as "grey Billy" or "shin cracker," until he reaches a thin band of hard strata. As the "opal dirt" is under this, he makes the band the top of his side tunnels. This is about forty feet below the surface and the shaft leading to it is cut to about three by five feet. The miner, dangling at the end of a cable, is lowered by a windlass to the working level. As he goes down a cowhide bucket filled with opal dirt comes to the surface. He works in the side tunnel until his pick strikes hard material. A gouge is then substituted for the pick. This is a small pointed piece of iron about six inches long. It has a loop in the center to hold a candle which enables the miner to see any glint of opal as he digs into the dirt. The use of this tool has gained for the miner the title of "gouger." Some of the opal is found in layers, some in pockets. If a pocket yields good opals they are known as "nobbies." If worthless stones are found they are called "potch."



Courtesy Percy Train, M.E., Denio, Oregon

WEST ENTRANCE TO RAINBOW RIDGE OPAL MINE IN THE VIRGIN VALLEY, HUMBOLDT COUNTY, NEVADA

The Australian opal mines are officially recorded as having produced £2,000,000 worth of these gems, but this does not include many marketed privately. Two of the largest pieces of opal in existence, weighing 9512 and 6805 carats, respectively, came from this district.

Courtesy Percy Train, M.E., Denio, Oregon

A SURFACE OUTCROP OF OPAL STRATA IN THE VIRGIN VALLEY OF NEVADA

Mexico is noted for its brilliant fire opals, but produces the commoner varieties as well. The chief mines are in the states of Querétaro, Hidalgo, and Chihuahua. The Mexican prospector looks for the glint of opal which has been exposed by weathering processes. These surface indications, called "pintas," are mixtures of opal and white silicious sinter which fill cavities in rhyolite. Many of these mines are worked by open quarry methods. In one case (*12*) a twenty-five-foot layer of opal dirt lay under a fifteen-foot layer of rhyolite. This dirt was removed by undercutting methods as long as this was safe. The rhyolite layer was then blasted loose and removed.

The best as well as the greatest variety of opals in the United States is found in Nevada. There is only one other location in the world where wood has altered to fire opal. This field lies in the Virgin Valley of Humboldt County. As this is just across the line from Oregon the valley may be reached via either Winne-

Courtesy Australian National Travel Association
SECTION OF THE LIGHTNING RIDGE OPAL FIELD, AUSTRALIA

mucca, Nevada, or Denio, Oregon (*13*). It is about twenty-five miles from Denio. The opals occur in yellow clayey beds accompanied by fossil remains. These beds lie on rhyolite and are covered by basalt flows. The chief mining operations have been carried on at the Rainbow Ridge camp. These workings occupy the summit of a low rounded hill in which the opal-bearing strata outcrop near the top. Mining is done by tunnels and drifts. It is not necessary to go down more than fifty feet. Most of the opals are scattered. A few are found in pockets. When freshly mined they are ice cold and glow like living flames in the light of miners' lamps. In 1919 a black opal weighing 16.97 troy ounces and valued at a quarter of a million dollars was found in this mine.

COMPOSITION AND PROPERTIES

Opal is formed in a variety of ways, but chiefly as a result of the decomposition of silicate minerals by hot waters. The dissolved silica is subsequently deposited in gelatinous form and hardens as the water is gradually expelled (*4*). This gives a product of the formula $SiO_2 \cdot nH_2O$. The water content may vary from 1% to 21% but is generally 6% to 10%. Like other amorphous minerals opals have often absorbed foreign matter. The compounds of calcium, iron, magnesium, sodium, and aluminum, as well as bitumens, are the impurities most commonly found.

Opals may be colorless, black, blue, gray, green, pink, red, brown, yellow, or white. The play of colors so often observed is the result of the breaking up of white light into its component colors. This is generally interpreted as being due to minute cracks or the presence of scattered patches which have a water content and hence a refraction differing from that of the main body of the mineral (*14*). Such cracks doubtless result from the drying out of the silica jelly. The scattered patches are caused by the deposit of another generation of silica in the cracks. Overheating may seriously impair this color display.

The hardness of opals varies from $5\frac{1}{2}$ to $6\frac{1}{2}$ on Mohs' scale. They cannot stand hard wear, but repolish easily.

They are isotropic, with an index of refraction of 1.44 to 1.45. The specific gravity varies from 2.1 to 2.3.

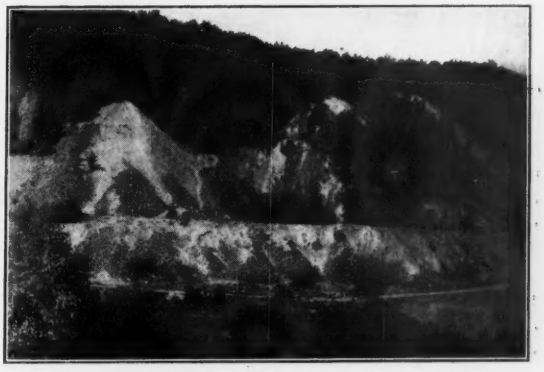
Opals are easily identified since no other gem stones have the same combination of color play, specific gravity, and index of refraction.

They have a vitreous, dull, or resinous luster. Opals are almost entirely soluble in hot potassium hydroxide solution.

Opals which carry considerable amounts of moisture when brought directly into the air, dry out too rapidly and fall to pieces. This may be prevented somewhat by burying them in oil or mud for some period of time. However, no scheme of tempering is as satisfactory as the "aging in place" which takes place in nature.

CLASSIFICATION

There are two chief classes of opals, the precious and the common. The precious or "noble" class includes the black, the white, the deep green lechosos, the yellow or red fire, the spotted harlequin, the blue-white with red color-play girasol, and the opal matrix. The common opals exhibit very little play of colors. They are subdivided into the milk, the yellow resin, banded agate, red or brown opal jasper, green prase, pink rose, brown or gray liver, colorless hyalite, cloudy-white hydrophane, blue-white cacholong, cauliflower-like geyserite, wood, moss, tabasher, and tripolite.



Courtesy the Ministry of Public Works, Czechoslovakia
THE OPAL VEIN "LIBINKA" IN DUBNIK NEAR CZERWENICA, CZECHOSLOVAKIA
For many years this was the chief opal mine in the world.

SUBSTITUTES

To produce a substance of the same chemical composition as the opal is an easy matter. To make one with the desired brilliant play of colors would be very difficult. As a result opals do not have to compete with "synthetics."

Attempts are often made to make one of the common varieties look like a precious opal. Soaking such an opal in oil and then subjecting it to heat gives a black imitation. But the product is fragile and the color

Courtesy Australian National Travel Association
AN OPAL "GOUGER" AT WORK IN LIGHTNING RIDGE MINE

may fade. A "doublet" may be made by sticking a thin layer of black "potch" on the back of a common opal. This improves the color but the product lacks the characteristics of a good black opal.

USES

The chief use of the opal is as a gem stone, although a few are made into paper weights and other ornaments. Slabs of opal-containing matrix are often polished for decorative purposes. If the opal happens to occur in thin layers on a brown ferruginous background it can be made into a very effective cameo.

If used as a setting it is always cut "en cabochon." The rough opal is first shaped on a grindstone and then finished off and polished with sandpaper and soft rough leather. It is well suited for pendants, brooches, and necklaces. When mounted in a ring the stone should be carefully protected by the setting (*4*). Mother-of-pearl or black silk makes a very effective background. It is said that the warmth of the body enhances the radiance of an opal and that it is more beautiful in dim than bright light. Many strange tales have been told of the freaks and foibles of opal color changes under various conditions.

While opal has occasionally been in disrepute, the predominating opinion of it has been that it was the source of all possible good. It was said to fade upon the insincere, deceitful, and impure. When worn by the innocent it was believed to combine the special virtues of all gems. It was considered an excellent eye remedy, as well as being credited with making its wearer a general favorite. It was the symbol of hope, innocence, and purity.

The price rests entirely with the buyer and seller. The valuation may vary from a few cents to many dollars per carat according to the quality of the specimen. "The Pride of Australia," a famous black opal weighing 225 carats, is valued at £2,000, but collectors' specimens of the more common varieties may be obtained very reasonably.

Opal is the accepted birthstone for October, for according to an old verse (*15*):

"October's child is born for woe,
And life's vicissitudes must know,
But lay an opal on her breast,
And hope will lull those woes to rest."

American Museum of Natural History, N. Y.
A GROUP OF SIX AUSTRALIAN OPALS

LITERATURE CITED

(1) BRIDGEMAN, H. B., "Gems," H. B. Bridgeman, 604 Carlton Ave., Brooklyn, N. Y., **1916**, p. 56.
(2) RAMSAY, A., "Bright jewels of the mine," *The Saturday Evening Post*, Sept. 15, 1934, p. 65.
(3) BAILY AND BAILY, "Etymological dictionary of chemistry and mineralogy," Edward Arnold & Co., London, **1929**, p. 191.
(4) AITKENS, I., "Opals," Dept. of Commerce, U. S. Bureau of Mines Information Circular 6493, Sept., 1931, 9 pp.
(5) JACKSON, C. F. V., "The opal mining industry and the distribution of opal deposits in Queensland," Queensland Dept. of Mines, Geol. Survey Report No. 177, **1902**.
(6) SAINT-SMITH, E. C., "Opal occurrences in the Springsure district," *Queensland Govt. Min. Jour.*, **23**, 188–9 (May 15, 1922).
(7) MCENELLY, T., "Discovery of an opal mine," Consular Report, Nov. 18, 1927, 3 pp.
(8) Bray, J. C., "Opal fields in Nevada," *Min. Am.*, Dec. 11, 1915, p. 4.
(9) KUNZ, G. F., "Precious and semi-precious stones," *Mineral Ind.*, 1923, p. 584.
(10) KUNZ, G. F., "Precious and semi-precious stones," *ibid.*, 1927, p. 511.
(11) HENRY, C., "Australia's opal fields," *Walkabout*, **1**, 23–7 (Jan., 1935).
(12) MACFARLANE, T. M. M., "A description of a Mexican opal mine," *Eng. and Min. Jour.*, **92**, 842 (Oct. 28, 1911).
(13) MELBASE, J., "Nevada, the mineral collector's mecca," *Oregon Mineralogist*, **2**, 5, 6 (Sept., 1934).
(14) KRAUS, E. H. AND HOLDEN, E. F., "Gems and gem materials," McGraw-Hill Book Co., New York City, **1931**, pp. 166–8.
(15) FARRINGTON, O. C., "Gems and gem minerals," A. W. Mumford Publishing Co., Chicago, **1903**, p. 59.

ON *the* EARLY HISTORY *of* LIEBIG'S LABORATORY

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LIEBIG was not the first to develop a laboratory in which students experimented. Indeed, there was no first. The beginning of laboratory instruction whether in chemistry or in other sciences, is as hard to date with accuracy as the invention of printing; and for the same reason, namely, that it began as a gradual process to which many independent workers made nameless contributions before anyone became aware of the development. Whether Purkinje actually had a physiological laboratory for students at Breslau in 1823 is still doubtful.[1] But Amos Eaton had a general laboratory in the Rensselaer School at Troy, New York, in 1825.[2] We may call this a general laboratory because Eaton taught the applications to agriculture, industry, and the household, of several sciences, including chemistry. His students performed experiments but their purpose was to learn the practical uses of science, not to advance the sciences. No discoveries were announced from Eaton's laboratory, although several of the men whom he trained later became investigators.

Others have regarded Thomas Thomson as the pioneer in opening the chemical laboratory to students. Ernst Von Meyer was of this opinion for he wrote that the first, although very small, laboratory giving young men opportunity to experiment was that of Thomas Thomson, which was opened at Glasgow in 1817.[3] This was the year of Thomson's appointment to the newly established chair of chemistry at the University of Glasgow and a year later he was made Regius Professor. But Thomson had taught chemistry at Edinburgh at an earlier period. Walter Crum, in giving an account of that time, wrote: "Dr. Thomson [beginning in 1801] continued to lecture in Edinburgh till 1811, and during that time he opened a laboratory for pupils, probably the first established in Great Britain."[4]

Almost contemporary with Thomson was Friedrich Stromeyer, the discoverer of cadmium,[5] who began teaching chemistry at Göttingen in 1810. One of his later students has left an account of his manner and method, as follows:

".... A vigorous, engaging voice makes it possible to follow his words in every part of the auditorium. Everything that he says shows his clear intellect and the certainty of his knowledge. He is a very superior teacher. He never says too much or too little, always with liveliness, in each and every lecture. No experiment of his ever miscarries; his accuracy shows itself even from the fact that he begins his collegium and closes it on the exact minute without ever losing the thread of his lectures... He owes his widespread fame to the extraordinary accuracy of his analyses, which he never tired of repeating until he had secured complete agreement in the results and which he has published in numerous scholarly papers. From the very beginning of his academic career he followed the principle that chemistry can be learned only by actual practice and that opportunity must be offered to the students to make their own analyses. For professional chemists he lectured on analytical chemistry in a course which extended through three semesters. After he became director of the chemistry laboratory he introduced practical exercises into the work. Through him Göttingen became the first German university that was able to offer such facilities. This analytical laboratory attracted many students and had to be enlarged again and again...."[6]

We can find still earlier examples of student laboratories of chemistry.[7] It was in the spring of 1799 that

[1] See addresses by H. NEWELL MARTIN on "Modern physiological laboratories," *Science*, **3**, 73–6 (Jan. 18, 1884); and DR. WILLIAM H. WELCH on "The evolution of modern scientific laboratories," Annual Report, Smithsonian Institution, **1896**, pp. 493–504. The best available study of Purkinje is by E. THOMSEN, "Uber Johannes Evangelista Purkinje und seine Werke," *Skandinavisches Archiv für Physiologie*, **37**, 1–116 (1919). Thomsen reports Purkinje's appointment as Professor of Physiology and Pathology as due to "Goethe's powerful recommendation" which "overcame all opposition to the Czech." On Goethe's regard for Purkinje's early work see "Werke," Herman Böhlau, Weimar, **1887–1896**, Vol. 61, pp. 269–84. Thomsen says Purkinje was coolly received and was compelled to establish a laboratory in his own residence; but this was a very common arrangement in German universities at that time. *Meyer's Lexikon* (17th ed., Leipzig, 1928, 9, 1411–2) in an account of Purkinje partly based on the above says that he founded in 1839 at Breslau the first physiological laboratory. Obviously we need not only more facts but better definitions.

[2] P. C. RICKETTS, "History of the Rensselaer Polytechnic Institute, 1814–1914," John Wiley & Sons, New York, **1914**, esp. pp. 11–4 and 31–5; also by the same author, "The first chemical and physical laboratories for the use of individual students," *Rev. Sci. Instruments* [N. S.], **4**, 571–4 (Nov., 1933).

[3] ERNST VON MEYER, "Geschichte der Chemie," Veit & Co., Leipzig, **1889**, p. 444. English translation from the third German ed. by G. MCGOWAN, Macmillan & Co., London, **1906**, p. 648.

[4] WALTER CRUM, "Life and labours of Dr. Thomas Thomson," *Proc. Phil. Soc. Glasgow*, 51st Session, Nov. 3, **1854**, p. 252.

[5] MARY ELVIRA WEEKS, "The Discovery of the Elements," republished from the JOURNAL OF CHEMICAL EDUCATION, Mack Printing Co., Easton, Pa., **1934**, p. 135.

[6] GEORG FR. L. STROMEYER, "Erinnerungen eines deutschen Artzes," Carl Rumpler, Hannover, **1875**. The quoted passage is here translated from an excerpt in J. ZIEHEN, "Aus der Studienzeit, Ein Quellenbuch zur Geschichte der deutschen Universitäts-Unterrichts," Weidmannsche Buchhandlung, Berlin, **1912**, pp. 423–4. It was in Stromeyer's laboratory that Edward Turner, about 1822, worked for two years. We shall see below that Turner seems also to have worked with Liebig. Dr. Georg Stromeyer, author of the quoted passage, was a nephew of the chemist.

[7] Among the earlier laboratories in which experiments were performed by teachers and possibly by students, we name Hoffman's at Altdorf in 1682 (ORNSTEIN, MARTHA, "The rôle of scientific societies in the seventeenth century," University of Chicago Press, **1928**, pp. 175*f*; 230*f*); Peter Sthael's at Oxford about 1663 (BLISS, PHILIP, editor, "Athenae Oxoniensis," by

Berzelius, a medical student at Upsala, begged for permission to do laboratory work, but the professor tauntingly asked him whether he knew the difference between a laboratory and a kitchen and gave him a book to read. "It appeared to me," wrote Berzelius, "that his purpose was to discourage me." But Berzelius was hard to discourage. In spite of routine preparation-making and desperately poor lectures he became a chemist, made a very good laboratory out of a kitchen, and wrote his own books. The point is that there was a laboratory. "For two years," he wrote, "I remained with the general laboratory workers, toward the end, however, chiefly to carry out at the laboratory what could not be done in my own room." Eight years later, in 1807, he "introduced exercises in pharmacological and chemical operations similar to those at Upsala," into the medical school at Stockholm.[8] To find the beginnings of chemical laboratory teaching we must apparently study the history of schools of pharmacy and medicine.[9]

Two things were happening to the subject of chemistry in the generation before Liebig: it became scientific, developing methods and laws, and it became useful not only in medicine, but in agriculture and industry also. It was, indeed, just beginning its career of creating new industries. By becoming scientific it also became teachable; and by becoming practically useful it attracted students in large numbers. The teaching laboratory was the inevitable result. And although Liebig did not invent it, he was present at the historical moment when it permitted and deserved exploitation. Not only was he there at the right moment but he was a very competent promoter as, indeed, he had to be to overcome the difficulties amidst which he was placed. Although Lord Kelvin's pronouncement that "all the eminent chemists who were young in 1845 were pupils of Liebig"[10] is a great exaggeration, yet it is true that the Giessen laboratory was the most influential center from which the new method of teaching chemistry spread.

Many scientists, even the greatest, and beginning, let us say, with Aristotle, have been teachers. Nor has this circumstance changed. Most of the Nobel prizes, in chemistry and physics, at any rate, have been awarded to professors. Teaching is, however, a broad term and some of the great investigators were not good teachers, or willing ones, of crowds of ignorant and idle boys. We have just mentioned Lord Kelvin. A comparison of Kelvin and Liebig as teachers would have some interest. In one respect, at least, they were alike—their lecture-experiments did not always come out right. We shall see that this was true of Liebig. And one of Kelvin's students has told how his haste and impulsiveness before a class played havoc with his experimental illustrations. "Faraday's result was so and so," he would say, "remember that, not what we got today."[11] But although the scientists have frequently been teachers, yet the historians of science have very little to say on science-education and usually nothing at all about the laboratory as an educational instrument. The English language is very poor in accounts of the rise and development of the laboratory, although Cajori has a section on chemical and physical laboratories in his *History of Physics*.[12] But this is unusual. The Germans have done only a little better; but the history of Liebig's laboratory has been told in some detail by his biographer, Jacob Volhard, and others.[13] The few English accounts of the same topic are both fragmentary and inaccurate. Even the actual date of its establishment and its whole development are matters upon which well-known writers disagree. The excerpt which we translate below throws some light upon this topic, and it also contributes to our knowledge of Liebig, the man, the teacher, and the scientist.

The passage is by Carl Vogt (1817–1895), professor and politician, and is taken from his unfinished autobiography, *Aus Meinem Leben: Erinnerungen und Rückblicke* (Stuttgart: E. Nägele, 1896.)*

ANTHONY À. WOOD, London, **1813,** pp. lii–liii); the Ashmolean "elaboratorie" of 1683 [T. E. JAMES, *Nature,* **131,** 716–7 (May 20, 1933)]; and from the next century, the laboratory of the physicist and chemist, M. V. Lomonósov (1711–1765). This last-named laboratory was established at St. Petersburg in 1749. Here Lomonósov carried out technological work, lectured on chemistry, from 1751 on, to students of the University, and here he is said to have "instituted the very first known laboratory exercises in physical chemistry, consisting of experiments performed by students under his supervision." [MENSCHUTKIN, B. N., "A Russian physical chemist of the eighteenth century," J. CHEM. EDUC., **4,** 1079–87 (Sept., 1927).] On Lomonósov see also No. 178 of Ostwald's *Klassiker der exakten Wissenschaften,* edited by Menschutkin and Max Speter. A complete account would list still other predecessors of Berzelius, Thomson, and Stromeyer and might have to include contemporaries, such as Dr. Marcet, at Guy's Hospital, London. One is doubtful about Turner; see *Gentleman's Magazine,* 423–4 (Apr., 1837).

[8] H. G. SÖDERBAUM, "Jöns Jacob Berzelius, autobiographical notes," translated by OLOF LARSELL, Williams and Wilkins Co., Baltimore, **1934,** pp. 23–7.

[9] R. WINDERLICH'S sketches of Liebig and Wöhler in Günther Bugge, "Das Buch der grossen Chemiker," 2 vols., Verlag Chemie, Berlin, **1929, 1930.** See, in vol. 2, pp. 23, including footnotes, 47, and 48.

[10] SIR WILLIAM THOMSON, "Scientific laboratories," an address, *Nature,* **31,** 409–13 (Mar. 5, 1885).

[11] W. E. AYRTON, "Kelvin in the sixties," *Popular Sci. Monthly,* **72,** 259–68 (Mar., 1908). Other student opinions and collateral matter are found in S. P. THOMPSON'S "Life of William Thomson," Macmillan and Co., London, **1910,** pp. 193 *n.*, and 1131 *n.* See also PROFESSOR E. F. SCOTT'S remarks in "Contemporary American theology," edited by V. FERM, Round Table Press, New York, **1932,** pp. 34–25.

[12] FLORIAN CAJORI, "A history of physics in its elementary branches including the evolution of physical laboratories," The Macmillan Co., New York, **1929.** (First edition, **1899.**)

[13] JAKOB VOLHARD, "Justus von Liebig," Barth, Leipzig, **1909,** 2 vols. Volhard was a pupil of Liebig's and later his assistant and colleague. He had the use of a pamphlet by G. Weihrich entitled *Beiträge zur Gesch. des chem. Unterrichts an d. U. Giessen* (Giessen, 1891) and other published and unpublished materials.

H. KOLBE, "Zur Erinnerung an Justus von Liebig," *J. prakt. Chem.* [N. F.], **8,** 428–58 (1874); and also the article preceding this one.

ERNST VON MEYER (note 3, preceding) has a good, brief account.

* There are at least three public copies in the United States and, no doubt, more. The three are in the New York Public Library, the Library of the University of California, and that of the Museum of Comparative Zoölogy at Harvard University. It was, however, in Ziehen (see note 6) that I first came across the passage about Liebig.

Vogt was born in Giessen and spent his youth there, where his father was a physician and professor of medicine in the university. As indicated in the quoted passage he attended the university for about two years. He entered as a student of medicine, but Liebig almost succeeded in making him a chemist. In the summer of 1835 he became involved in political agitation and fled to Switzerland. From 1839 he was engaged in the glacier investigations of Agassiz and Desor and during this period he prepared for the press the first and part of the second volumes of Agassiz's work on the *Fresh-Water Fishes of Central Europe*. His opinion of Agassiz is not altogether favorable, rather the contrary. Through Liebig's recommendation he was appointed to a professorship of zoölogy at Giessen in 1847 but was soon again driven out of the country because he stood with the extreme left in the activities of the Frankfort parliament. After 1852 he was professor of geology and later also of zoölogy at the University of Geneva. His writings, even his scientific ones, are bombastic and pugnacious. His son, William Vogt, wrote his biography (*La vie d'un homme*, Paris, 1896).

Aus Meinem Leben is written in a piquant, gossipy style and reveals a highly individualistic personality. It describes and recounts the *Kleinbürgerleben* of a provincial German university of six thousand and is a source of some importance on the University of Giessen a century ago. It paints a picture of Liebig and his laboratory as seen by a single pair of eyes and those very friendly to the great chemist. One must also recognize that an account written a half-century after the events is certain to err in details; but I see no reason for doubting Vogt's substantial accuracy except his too great desire to tell a good story. No doubt, as Volhard would insist, he tends to exaggerate—the special vice of the raconteur—but Volhard does not really make much of a case against him. A detailed criticism would require too much space.

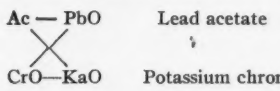
The passage which follows, and which seems not to have been translated into English before, comprises the complete text of *Aus Meinem Leben* of pages 120 to 133 except for minor omissions which are indicated.

Carl Vogt wrote:

During the first Winter semester, I attended only Wilbrand's* lectures in human anatomy, dissected when cadavers were available which happened but seldom and followed at the same time the private instruction of Prospector Wernekinck† on comparative anatomy. Wernekinck, a genial, heavy-set man, a distinguished violoncellist and excellent preparator had no great respect for the anatomical knowledge of his superior; and he possessed a personal collection of preparations which he never placed at the service of his chief. "He understands nothing of it," he said, "and everything breaks in his awkward hands." This private course interested me very keenly. Wernekinck demonstrated for us the current theories of the vertebrates and took all possible pains to introduce us into the inner secrets of the comparative anatomy of Cuvier and Meckel.‡ This was accomplished the more readily as he had only three students: a Hollander by the name of Kratz, myself, and Georg Büchner,** the author of "The Death of Danton," whose life came to an early close while he was privat-dozent of comparative anatomy at Zürich....

In the Summer semester of 1834 I heard Wilbrand lecture on botany and physiology and Liebig—who at that time was only an ordinary professor and had not yet been created baron—on experimental chemistry. In botany Wilbrand marked me: "Industrious and Attentive"; in physiology, only: "Industrious." Wilbrand taught the Linnean system thoroughly; and his students passed in review a great many plants which he had the assistants bring in great quantities from the botanical gardens. There were also weekly excursions in the vicinity which were very instructive even though Wilbrand, who always carried his manual with him in a leathern case, was hardly on speaking terms with several of the plant-families. He ran on ahead like a greyhound and always took strides of twice his usual length past the places where our Lord God had shown unusual prowess in creation....

But I was already spoiled for physiology of the Wilbrand kind.... I, indeed, attended the lectures regularly; but attentive, Wilbrand could certainly not call me! Liebig's lectures attracted me so much the more. He was then at the height of his power and enthusiasm and his every word proclaimed his determination to give us the most thoroughgoing instruction. The lectures were, certainly, not models whether one considered the descriptions, the performance of the experiments, or the derivation of the conclusions and inferences. Liebig was at that time still overhasty in everything that he undertook. He was very prone to leave out the intermediate steps of a course of reasoning. Starting out from a major premise he instantly came down with both feet plump upon the final conclusion. In the lecture experiments he constantly seized the wrong materials or succeeded only because the assistants on the right hand and the left placed the proper instruments and reagents into his hands. The excellence of his manipulation in the laboratory was equaled only by his lack of success in the lecture-demonstration; and yet in spite of these defects we were carried along and inspired by his ardor for his subject. "Now, gentlemen, I have a liquid in this test-tube. It is a solution in water of acetate of lead. You might believe it to be water—it appears just like water—but I would be able to show you that it is a solution—for the present you will have to take my word for it. Well then, this water is a solution of lead acetate! And here in this glass, you see a yellow liquid! (Takes the glass and looks at it.) That's right! A yellow liquid! This yellow liquid, it is a solution of potassium chromate in water. (He puts down both glasses, goes to the blackboard, takes the chalk and writes):



It will be all the same whether I put down the atomic weights or not, you don't understand that now. But you do understand that this is acetate of lead and this, chromate of potassium. Now, gentlemen, I pour the two liquids together. (He pours them together, goes to the board and draws the cross-lines.) You see, a chemical decomposition takes place. The acetic acid combines with the potassium and forms acetate of potassium which is soluble in water and colorless; the chromic acid combines with the oxide of lead and forms lead chromate which is insoluble

* WILBRAND, JOH. BERNHARD (1779–1846). Professor of Anatomy, Physiology, and Natural History and Director of the Botanical Garden. According to Liebig he was more strongly infected with the prevailing nature-philosophy than Oken himself.

† WERNEKINCK, FRIEDRICH C. G. (1798–1835). Prosektor in Anatomy and, after 1826, Professor of Mineralogy. During Liebig's first years at Giessen, he and Wernekinck together conducted a chemical practicum eight hours a week.

‡ MECKEL, JÖH. FRIEDRICH (1781–1833). Celebrated German anatomist; studied at Halle, Göttingen, Würzburg, and Vienna, and visited France and Italy. Professor of Medicine, Anatomy, and Physiology at Halle from 1806.

** BÜCHNER, GEORG (1813–1837). Poet and dramatist; studied medicine at Giessen, 1833; published various socialistic and revolutionary pamphlets and poems, including *Dantons Tod, dramatische Bilder aus der Schreckzeit*, Frankfort, 1835.

in water and produces a beautiful yellow precipitate which is used as a dye, as chrome yellow! (He shakes the glass and goes, constantly shaking it, up and down, along the front row of the students, all the time repeating: "Chrome yellow! A beautiful yellow precipitate! You see, gentlemen, you see!" At last he raised the glass and held it in front of his own eyes. "That is, you see nothing, the experiment has failed." (In a rage he throws the glass into a corner.) Ettling,* the assistant, shrugs his shoulders without speaking and points to a glass still standing on the table as a way of telling the students: "The Professor in his zeal has again used the wrong solution."

At the end of the first week Liebig announced that each Saturday afternoon he would conduct a weekly examination to which he invited all those who took a serious interest in chemistry. For the first examination the lecture-room was full. He examined very rigorously, probed down to the very foundations of the topics, and any who could not answer he left sitting with their mouths open. For the second examination there were, in addition to those who worked in the laboratory, only about twenty persons; and for the third the laboratory students also did not appear—we were five men, altogether! Liebig with a sly smile said: "Now the chaff has separated itself from the wheat! We shall not carry the examination further, gentlemen. But since I see that you take a serious interest in the science I invite you to come into my laboratory. You shall have places there. You will choose with regard to the schedule of your other lectures the days and hours when you will wish to work in the laboratory. My assistant, Mr. Ettling, will give you the necessary instructions and will be of use to you in your first efforts."

Thus I entered the laboratory which at that time was still in the first stage of its growth. Only a few students were found there. Sell† and Blanchet,‡ perhaps the first to work with Liebig for any considerable period, had just left. Among those whom we found there, our comrades for the first semester, I can still recall by name a mercurial Frenchman, Demarçay**. With alleged witticisms, uttered in his comical broken German, he continually persecuted a Pole of somewhat limited understanding whose name I have forgotten. The laboratory consisted of a work-room with a colonnade at the front. Scant space for about twelve workers was found at tables set under the windows. In the middle there was a large stove on which and in which crucibles and retorts could be heated. Behind the hall there was a room crammed full with equipment and supplies; behind this a second room where the apparatus for glass-blowing was kept and where the anvils for fashioning platinum crucibles and also the balances were set up. Opening into the corridor which led into the latter room was Liebig's own work-cabinet and a small private laboratory in which there was room for two or at most three persons. Above the laboratories were the very limited quarters of Liebig's private dwelling. That was all there was. Coal was used for heating, since gas was still unknown. So also were friction matches. Fire was obtained by means of asbestos dipped in strong sulfuric acid. The present conveniences of the great laboratories of our time had not yet been discovered. Everyone had to blow his own glassware, cut his own corks and bore holes through them, make his own tubing from pieces of rubber, and forge his platinum crucibles. Perhaps a good deal of time was lost in these ways; but one learned to deal with these arrangements and to manage with meager resources ... our decadent successors from the great laboratories of the present are, by comparison, raised in luxury ... and seem to lack our adaptiveness.

Ettling, the assistant, was a model teacher of all the manual skills. He was an older man who had been an apothecary and he had carried over from this calling an almost painful and pedantic attention to exact detail which stood out in extreme contrast with Liebig's active, restless, and always aggresive nature. In Ettling a keen understanding was joined with a degree of quiet composure and patience the like of which I have since seldom seen. In spite of these very different characters the two men worked together ideally. The beginners were left entirely to Ettling's direction and when on occasion Liebig in his anxious haste interfered with their work the assistant was patience personified. Later he might indeed complain: "The Professor spoils my students." Ettling's instruction began with a fundamental introduction, the grinding of a cork-knife to a very sharp edge; and proceeded to the cutting and drilling of the cork and finally to the use of the blow-pipe in blowing glass and bending it. Glass-blowing, together with the guitar which he played like a virtuoso, was Ettling's hobby and prime achievement. All those elegant pieces which go under the name of Liebig's potassium-apparatus were made by his skilful hands. When, in two or three afternoons, these preparatory studies had been completed then Ettling took the beginner and stationed him in front of some shelves which held a row of flasks marked with the letters of the alphabet, put Rose's *Introduction to Qualitative Analysis* into his hand and said: "Well! Now you will take about so much from bottle A into a glass. This is your place. You will find here everything necessary for your work and in the Rose you can read what you must do. Tomorrow you will tell me what is in the glass."

And there one stood like butter in the sun. If he turned to an older student for aid he received merely a shake of the head or at most the admonition: "Do exactly what it says in Rose." Making mistake after mistake one got along as he best could. On the following day, Ettling came saying: "Well?" One bowed; he pointed out the mistakes; showed point by point where one had strayed from the right path and asked to have the work done over. Thus wretchedly, almost despairingly often, one struggled with the first letter; but gradually by reflection and the racking of one's brains progress was made. As the summer semester drew to a close I also had solved the riddles of my twenty-four bottles and now knew that in qualitative analysis, I was able to do a man's work.

Ettling, well content, took me to Liebig in his private laboratory and said: "Professor, Mr. Vogt has completed the alphabet.††† I think he has earned a platinum cup." (The gift of a pocket cup with a platinum blade for evaporations and blow-pipe studies was, in the laboratory, esteemed about as highly as a formal decoration.) "Certainly," said Liebig and brought a platinum cup from a drawer; handing it to me he looked at me for a moment with his large gleaming eye. "You must become a chemist," he said. "I will speak to your father. You understand?"

"Hm!" said my father when I told him the incident. "Liebig must again have had a sleepless night! Yet after all! It can do you no harm to study chemistry thoroughly! On the contrary!" Soon Liebig himself appeared with hasty step and after a short discussion the two agreed that in the autumn I was to abandon all other lectures and studies to devote myself wholly to work in the laboratory where a place was reserved for me.

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* ETTLING, CARL JAKOB (1806–1856). Officially appointed assistant to Liebig in the Spring of 1835 but may have been working at Liebig's own expense before. The first of the Liebig "Kali-Apparäte," which he prepared, was long kept as a show piece in the laboratory (Volhard, I, 222–3). He became science teacher in the Giessen Realschule and ultimately Professor of Mineralogy in the university.

† SELL. Unidentified. Possibly Karl Ludwig Sell (1810–1879) who received the doctor's degree at Giessen in 1832 but in law and jurisprudence and was for twenty-five years professor in that faculty at Bonn. His son, Eugen Sell (1842–1896) was Professor of Chemistry at the University of Berlin and was a figure of some importance in applied chemistry. Volhard (I, 85) calls the "Sell" of Vogt's text "der Techniker Sell."

‡ BLANCHET, RODOLPHE (1807–1864). Botanist, Lausanne. Dedicated a monograph with the title, *Influence de l'ammoniaque et des sels ammoniacaux sur la végétation* (1843), "À monsieur Liebig ... de votre devoué élève, Rod. Blanchet."

** DEMARÇAY, MARC HORACE (1813–1866). Followed a political career, held various important offices including that of Member of the Constituent Assembly of 1848. See *La Grande Encyclopédie* under Demarçay (Marie-Jean, baron).

††† "The alphabet." As this collection of made-up compounds increased, the alphabet proved inadequate and the series was called "The Hundred Bottles." The course in qualitative analysis was just beginning to take form when Vogt worked in the laboratory.

It was a new and joyous activity that we carried on first under Ettling's, then under Liebig's, guidance. The latter drove us incessantly. "You have filtered? Have you washed out the precipitate? Not yet? Meanwhile you may start another analysis! Here Wernekinck has given me [some] tachylith—he wants to know whether it really contains uranium. Will you investigate it at once!" "If things are to go on at this rate," said Ettling, "we shall have to reserve three places for Mr. Vogt so that he may have room for his glasses." But by that time Liebig was already occupied in setting tasks for another.

The laboratory gradually filled up more and more. After a while Liebig admitted me into his private laboratory where his own assistant, A. Strecker,* later professor at Tübingen, was working, where the Englishman Turner† had first worked and E. Regnault‡ later. Turner,† a very well-known chemist, was a walking corpse. He suffered terribly from insomnia and his digestion, ruined by long residence in India, was so bad that he could eat only a little rice which he carried about with him in a silver box and ate with a small ivory spoon. He sat, often entirely exhausted, imperceptibly breathing, in an armchair before his test-tubes with hardly enough strength to stir a precipitate. If he wished to wash out something in a filter it was necessary that someone should use the squirt-flask for him. When he spoke on chemical problems the corpse did vivify itself a little but only to sink again into complete prostration. Liebig treated him with the utmost consideration—we did for him what we could anticipate that he would wish done—but yet it was an uncomfortable sensation, this daily association with a man for whose final breath one had to be always prepared.

Quite otherwise was E. Regnault, the renowned French physicist. A small elegant lad, very young-looking, with long blond curls—one might have thought him fresh-baked in a North-German gymnasium and just entering the university, when as a matter of fact he had already finished the Polytechnic and School of Mines in Paris and was on his qualifying journey through Germany. He attracted everyone by his handsome face with large, blue eyes and his neat and elegant figure, while his calm and serious demeanor contrasted favorably with the restlessness of his fellow-countryman Demarçay. He came with a letter of introduction from Gay-Lussac for whom Liebig had an extraordinarily high regard. He had intended to remain only a few days; but Liebig persuaded him to devote some time to the acquisition of the methods of organic analysis which were at the peak of their development just then. Regnault stayed; and when his time had run out and his work was still unfinished, Liebig's intercession secured him an extension of his furlough....

(Rest of paragraph tells of Regnault's trick of twisting a lock of hair whenever he had either hand free.)

Agreeable as the work in Liebig's private laboratory was, it had its undesirable side. Every visitor had to go through the little room and whenever the voices became at all loud one could not avoid hearing everything. Two incidents which have thus remained in my memory offer vivid testimony in regard to some of Liebig's views.

Madame Liebig suffered frequently from migraine so that the dear, good lady was almost driven to despair. My father successfully treated Liebig for insomnia while the rest of the physicians of Giessen exhausted the pharmacopœia without being able to relieve his wife's sufferings. At last Madame Liebig, to the vexation of her husband, placed herself into the hands of the homeopathic sect which at that time in Giessen had its best-known prophet in the person of a court-councillor Rau. One day this man entreated Liebig to have chemically pure metals in powder-form prepared for him. He found, he said, that the administering of his pills did not always produce the effects which Hahnemann had set down in his medical works and was therefore led to suspect that the metals which he purchased at the apothecary's were not chemically pure. Liebig with the greatest amiability placed his scientific knowledge and his laboratory at Mr. Rau's service, merely asking him to make a list of the metals which were to be prepared. We got these substances ready for him. Some months after Mr. Rau came again, radiant with joy, and disappeared into Liebig's cabinet. Soon we heard a lively exchange of words; the door opened, Rau shot out of the cabinet like an arrow and Liebig appeared on the threshold shouting with laughter. He had mixed up the labels completely, which was not difficult with a series of metals extracted from precipitates. Mr. Rau had administered copper instead of gold, bismuth instead of antimony, and so on and had now come back to thank Liebig. With the chemically pure metals he had attained exactly the results which Hahnemann had led him to expect!

On another occasion a large, strong man brought his son. He was one of the cotton princes from Mülhausen and as he had a loud resonant voice one heard every word. He came to beg Mr. Liebig, he said, to take his son as a student. This one was to be placed in charge of the dye-department in the manufactory; another son was at the head of the weaving department; and a third directed the spinning. Would Mr. Liebig, therefore, please instruct his son in colors and coloring? "I am no dyer," answered Liebig; "and I cannot use your son. Take him back with you and place him in a dye-house." The man began to plead and Liebig vigorously repeated his refusal. When the man began to sob, we heard finally how Liebig gave in. "I direct a chemical laboratory," he said, "and no dye-house. But I will tell you! If you are willing to leave your son here for two years and if, also, he has the capacity, I will make a capable chemist out of him. But he must remain two years and must occupy himself with chemistry and not with dyes. About dyeing he will learn nothing at all. But when he then comes back to you he will in fourteen days understand more about colors and coloring than all your dye-masters put together. Do you understand?" The man understood and had no cause later to regret his decision.

We were early invited to take part in our master's labors while he at the same time insisted that we must carry on our own investigations. "Nothing rouses greater enthusiasm in young people," he said, "than to see their names in print. The French have a wholly mistaken system. Every discovery that is made in a laboratory whether in Paris or in the provinces has to appear over the name of the professor in charge. That takes all the spirit out of the young investigators and, besides, the professor often has to be sponsor for absurdities which he did not commit. There is Dumas; he has been made to bear the blame for the errors of his assistants. Those who work with me publish under their own names even when I have helped them. If they announce an actual discovery some of the credit will after all accrue to me; the errors will be theirs alone. Do you understand?"

Liebig engaged upon a task, it might be an experiment or a piece of writing, knew neither peace nor quiet. "He writes the report," said one of his critics to me once upon a time, "while the crucible with the materials is still standing in the fire and at the instant when he burns his fingers in removing it he dispatches to the printing-press what he has written." But in spite of his haste he was an extraordinarily skilful and careful experimenter in the laboratory. The laboratory, of course, was thrown into complete disorder at the peak of his activity and in the fire of his ardor no one was spared. He appears, a small glass-flask with a stopper in hand. "Just bare your arm," he says to me. I do it; he shakes the flask and with the stopper dabs me on the arm. I feel a burning pain and plunge my arm instantly into a bucket of water. "Exactly! Doesn't it burn?" said he. "You see. I

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* STRECKER, ADOLF (1822–1871). Professor of Chemistry at Christiania, 1851, Tübingen, 1860, and Würzburg, 1870. Vogt must be mistaken in the man for Strecker was only thirteen at the time.

† TURNER, EDWARD (1798–1837). Important British chemist and teacher and from 1828, Professor of Chemistry at the University of London. See notes 7 and 8, above. If Turner worked in Liebig's laboratory it must have been during a vacation trip to the continent. The rest of the account may tally with Turner's condition by, say, 1835. He died of a pulmonary complaint. But I have not read that he ever lived in India.

‡ REGNAULT, HENRI VICTOR (1810–1878). Great French physicist and chemist. Vogt was mistaken in the initial letter. See S. P. Thompson's biography of Kelvin for a similar impression which Regnault made upon young William Thomson.

have just produced anhydrous formic acid. A drop splashed on my cheek and at once raised a blister. You see? Give me your arm also, Demarçay!" Several offered the arm. Ettling refused positively. "I can't blame you—I guess the gentlemen's arms will all be badly swollen tomorrow. This anhydrous formic acid is a corrosive (Ätzmittel)! All anhydrous acids must be corrosive because they instantly draw water from the tissues!"—I had received the largest portion and was compelled to have my arm in bandages for several days. Even yet it shows the circular white scar as a reminder of the discovery of anhydrous formic acid.

In the spring of 1835 Liebig called me into his cabinet. "I have this moment received a letter," said he; "it requests me to nominate a superintendent of a beet-sugar factory in Bohemia. Maintenance, salary of two thousand gulden and a percentage of the profits. Will you go?" "But for heavens sake!" I blurted out, "how could I do that? I know exactly as much about the whole business of sugar-making as a donkey knows of lute-playing. I am hardly eighteen years old. How much authority would I be able to exert? I cannot take it as seriously as you do!"—"I am entirely serious! Ask for a delay of three months before taking up your duties and prepare yourself for your work here in the laboratory in that time. Take it under consideration!"—"I have already considered it, Professor. I thank you but I will not go. Didn't you say, 'a ten-year contract?' I do not intend to waste my life in the Bohemian wilds." "You are right!" said Liebig. "After all any donkey has the ability to supervise a sugar factory. Strecker is to leave in the autumn and then you are to be my private-assistant. That will suit you better. You must prepare yourself for an academic career."

I did not become his assistant. An unforeseen occurrence drove me aside into other courses. In order to tell the story of these events it will be necessary to take up many things which I have so far deliberately omitted.

To recount the beginning of my connections with Liebig in their context is a matter that deeply concerns me. To him and to his inspiration I owe my interest in the sciences. When I came into his laboratory I was not yet seventeen years old, a greenhorn therefore whom it might have been even easier to mislead into evil ways than to guide into right ones. The partiality which Liebig cherished for my father may have contributed a good deal to the fact that he busied himself more with me than with others; but I can proudly affirm that his partiality for me also continued as long as he lived and that in later times after I had become a deserter from the chemical ranks he still exercised a not less truly fatherly care over me. In its proper place I shall tell how it was Liebig and he only upon whose demand I was called to Giessen as a Professor. From the beginning he had a perhaps too favorably opinion of me which he formulated as follows in my certificate of dismissal from the University of Giessen:

"Mr. Carl Vogt of Giessen, student of medicine, attended my lectures on experimental chemistry in the summer semester of 1834 and from the same semester until the middle of July, 1835, was also engaged in practical analytical investigations in the chemistry laboratory. I certify with pleasure that he has constantly devoted himself to the study of chemistry with extraordinary zeal and heartiness. I am certain that he will do superior work in every other department in which the work demands clear, sharp sight, understanding, and capacity. Justus Liebig."

As already indicated, we who studied chemistry exclusively formed a distinct clan in the University of Giessen. We worked in the laboratory from early morning until evening with the exception of Saturday afternoon when the frequently-named servant, Aupel,* attended to the necessary cleaning of the rooms. But he was often disturbed in this occupation because Liebig was apt to use this afternoon for investigations in which poisonous gases were produced or some danger, as of an explosion, was to be feared. Aupel was accustomed to say on such occasions: "I and the Professor carried out an experiment yesterday that might have cost us our lives." But on all other week-days the work went on without a break and Liebig alone was quite able to keep us busy. Nor did one feel compelled to live in high style. Towards noon we breakfasted at the neighboring rathskeller, not at any given time but as the experiments which were in process might permit; but in the evening we dined *en famille* at the Black Horse Hotel whose keeper at that time was a connoisseur in German white wines. This sociable meal led quite naturally to sociable evening walks in summer and sociable drinking-parties in winter. Thus one lived and moved almost exclusively in a society of chemists.

The constant association with so many aspiring men, some young and some older, but all entirely devoted to their special field could not but be extraordinarily stimulating to me. Many of my student comrades of those times have meanwhile become famous, have won for themselves lasting reputations as teachers of chemistry. When I went back to Giessen in the year 1847 a considerable number of that generation remained and thus the earlier associations could be revived; but if I am not mistaken Frederick Knapp,† in Brunswick, and I are now the only survivors of that time.

(He goes on to say that the philological studies of the gymnasium had been memory work almost exclusively; and because he had a good verbal memory he was not compelled to work in his school-days. The year in the laboratory made other and more serious demands upon him.)

In the laboratory it was quite otherwise. In the lecture-room Liebig taught rather infrequently; in the laboratory, not at all. But he possessed to the highest degree the power of arousing the investigational abilities of his students, to spur them on to the solution of problems and riddles and in apparently indirect ways to guide them into the paths which led them to their goal. His students, even in rediscovering what was already familiar, worked with the feeling that they were finding something new; and at the time when they were being directed to matters of fact and the inferences which could be drawn from them they felt the stimulus to further and independent research.

Among the students in the laboratory (*Laboranten*) there was always a certain number of younger men who cared nothing at all for student life and habits. Sons of manufacturers, technicians and merchants, etc., they sought the study of chemistry to lay the foundations of their future calling. Many of them could not at all conceive how one could strive after a poor public appointment, a settled position as the phrase was; there were indeed several among them who had been driven to choose a different course of life by the sight of their fathers' poverty as officials. The majority of those who had their names on the list of the laboratory students had not come by the usual educational route through the gymnasium and had not passed their leaving-examination (Maturitätsprüfung). Liebig was engaged in a continual and embittered struggle with the university pedantry which demanded the leaving-certificate and indeed the classical one as the indispensable prerequisite for admission to the university and its institutes, to which, to be sure, the laboratory also belonged. When the universal fame of the laboratory was once recognized then Liebig had of course won his fight; but this was at that time not yet the case and he seemed to most of his colleagues a destructive and pernicious element which should be restrained at any cost. In the medical faculty my father was the only one who energetically supported him.

Be this as it may, so much is certain, that these laboratory students, standing without the university circle to a certain degree, exercised a powerful influence upon their immediate environment and bit by bit transformed the common views regarding the numerous student conventions and traditions. . . .

* AUPEL or AUBEL. The servant who complained that there was no opportunity to clean the laboratory because it was in constant use (Volhard, I, 95); see also I, 107–8.

† KNAPP, FRIEDRICH LUDWIG (1814–1904). Professor in the University of Munich and the Hochschule Braunschweig; and superintendent of an important porcelain manufactory. Author of a widely used textbook on chemical technology and contributor to technology, especially of glass. Married Liebig's youngest sister.

The WASHING *of* TEXTILES

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PRESENT-day standards of personal hygiene require the periodic washing of one's clothing. Few of us now care to emulate the anchorites of yore who wore their clothes until the filthy rags fell from the festered backs. The measure of cleanliness of a people is a factor in the evaluation of their culture.

Early methods of textile cleaning included: beating on flat rocks, agitation with dry meal, boiling with potash, agitation with the crude soap obtained from kitchen grease, and potash liquor. The use of bleaches as whitening agents dates to the eighteenth century, when the use of Javelle water and Labarraque's solution was introduced. These same solutions of sodium hypochlorite are used today in the most up-to-date washing formulas.

Modern methods of laundering are based upon a consideration of the nature of the textile being laundered and of the nature of the soil upon the fabric. The protein fibers (silk and wool) receive a much milder treatment with respect to heat and agitation than do the cellulose fibers (cotton, linen, and rayon). This is to avoid the denaturation of the proteins with the resulting shrinkage of the wool or silk.

Essentially the washing technic consists of the dropping of the material into a pool of the cleaning medium. This is accomplished by revolving a cylinder with internal ribs which pick up the clothes at the bottom and drop them on the way to the top of the revolution. This allows the cleaning medium to be forced through the fabric without rubbing, beating, or straining of the fibers except that attendant upon the passage of the liquid through the cloth.

The successive steps in the washing process are based upon the nature of the probable soils. These soils may be roughly classified thus:

(1) Albuminous soils. These are coagulable by heat.
(2) Fatty, greasy, water-insoluble soils.
(3) Water-soluble (or dispersible) soils.

To deal with these diverse types of dirt a typical washing formula is given:

Operation	Temperature	Detergent or Added Agent	pH
1	35°C.	0.25% aqueous sodium oleate	10.5
2	60	0.25% aqueous sodium stearate	10.5–11.0
3	60	0.25% aqueous sodium stearate	11.0
4	60	0.1% sodium hypochlorite	10.5
5	71	none	10.5
6	82	none	10.0
7	82	none	9.0
8	82	sour and blue	6.5
9	30	none	7.0

It will be noted that the washing process is carried on in an alkaline solution. This is for three reasons: (*a*) to inhibit the hydrolysis of the soap solution, (*b*) to increase the dirt removal powers of the soap solution, (*c*) to neutralize acidic soils such as result from biologic processes. The alkalinity is achieved by the use of buffers: the alkali carbonates, phosphates, silicates, and fluosilicates are the buffers commonly employed. Except for special cases sodium hydroxide is not used in modern practice.

The temperatures employed are the basic factor in the washing formula. The first suds at body temperature, using the more soluble sodium oleate, is designed to remove the albumins and other heat-coagulable soils. Thereafter the temperature is raised to maximum detergent efficiency. The rinses are made at a still higher temperature to facilitate the removal of the last traces of dirt.

The bleaching operation, omitted in the case of colored goods, is a mild oxidation which produces a minimum tensile strength loss in the fabrics. This is in sharp contrast with home washing, where fabrics are usually overbleached with consequent loss of tensile strength.

The final operation is the neutralization of the alkaline washing solution. This is done variously through the addition of small quantities of bifluorides, silicofluorides, oxalic acid, or acetic acid. The object of this step is to avoid the harsh 'feel' and the skin irritation of the ironed alkali-containing fabrics. Since cotton is naturally somewhat yellow, a very dilute blue dye is added to the rinse water to give a faint bluish tinge to the cloth and increase the apparent whiteness.

Recent developments in the laundering of textiles which are not yet generally accepted, but which show definite promise, are:

(1) The use of complex metaphosphates to dissolve accumulations of hard soaps.

(2) The use of persulfates and hydrogen peroxide instead of hypochlorites in the bleaching operation.

(3) The use of coagulation inhibitors to permit the removal of albumins at a higher temperature with increased efficiency.

(4) The use of 'wetting out agents' such as the pine oil alcohols to increase the speed and efficiency of the penetration of the textile by the detergent.

(5) The use of the alkali metal salts of certain long chain alkyl sulfonic acids and alkali metal salts of long chain alcohol sulfuric acid. These detergents may be used in the presence of salt and at pH's around neutral. This diminishes the leaching out of dyestuffs and preserves the color of fabrics through more cycles of laundering.

PROJECTS *in a* HIGH-SCHOOL CHEMISTRY COURSE

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THE making of projects is always an interesting part of a course in high-school chemistry. Book reports, charts, scrapbooks, flow sheets, and exhibits of materials used in manufacturing processes constitute the project work of many pupils in the local school, but some choose to make models. Some of the models have proved unusually interesting and are described in this paper for those instructors who are looking for suggestions for this type of work.

Figures 1 and 2 show a hydrochloric acid factory. Parts of an old Erector set will be recognized, and a worn-out toy steam engine contributed the pipe and shut-off valve controlling the flow of water from the water tower. The absorption tower was once a vinegar bottle, while the three bombonnes were originally peanut-butter jars (the family of the model-maker evidently being fond of peanut butter). Figure 2 shows the manner of fitting the glass tubes which connect the bombonnes. A discarded Bunsen burner was repaired and given a side outlet, the open top end being plugged. This furnishes the heat under the Florence flask containing the sodium chloride and sulfuric acid. The cooling coil is shown in the center foreground of Figure 1. This model works, which naturally makes it more interesting.

Figure 3 is a photograph of a permutit water softener, another model which performs creditably and also clears up considerable mystery concerning the interiors

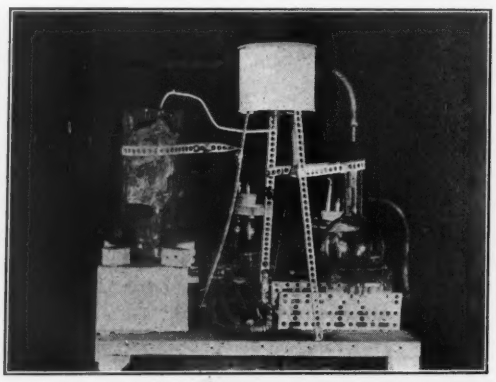

FIGURE 1.—HYDROCHLORIC ACID PLANT

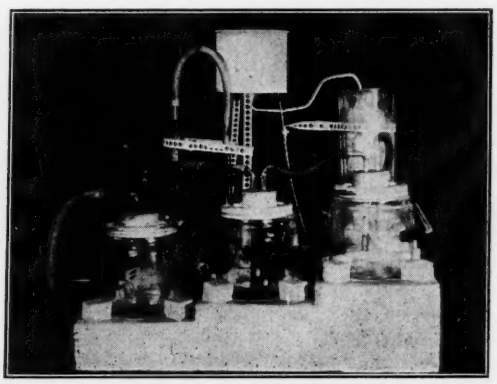

FIGURE 2.—HYDROCHLORIC ACID PLANT

FIGURE 3.—PERMUTIT WATER SOFTENER

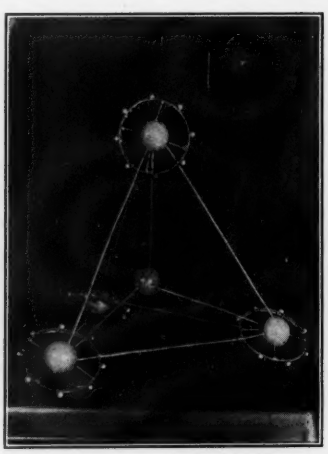

FIGURE 4.—MOLECULAR MODEL

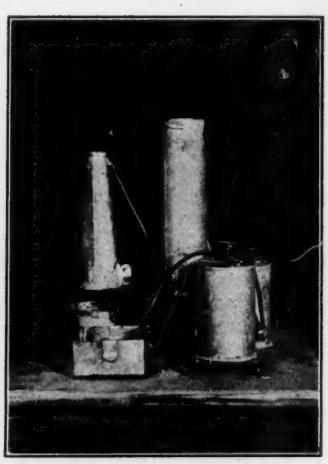

FIGURE 5.—SOLVAY SODA PLANT

of the commercial softeners. The bottle was cut in two in order to insert the screen and then cemented together later. Pinchcocks are used for valves and all inlets and outlets bear labels to explain their functions.

Figure 4 shows a model of an organic molecule made of rubber balls, wire, and beads.

Figure 5 will be recognized as a sheet-metal worker's version of a Solvay soda plant. The various units are all represented and, although this is not a working model, it is treasured as a worth-while addition to our visual aids in chemistry.

The JOURNAL OF CHEMICAL EDUCATION has published descriptions of projects in the past and our copies of these issues attest by their worn condition their popularity with the chemistry students. The writer hopes to see more articles on the subject.

A PROPOSAL FOR COÖPERATIVE JUNIOR RESEARCH

W. P. CORTELYOU AND E. HARTGE CORTELYOU

Alfred University, Alfred, New York

ANY chemist who has done a research problem can cite numerous bits of data he has had to determine for himself before he could go on with his major problem. Many have had to spend precious hours determining minor points missing in chemical literature because they were necessary to the solving of more important problems. A glance at even the most complete handbook will show an appalling number of blanks in the columns dedicated to such commonly used properties as specific gravity, melting point, boiling point, and solubility.

Often the material given is useless. Look at a solubility table, for instance! Unless one knows the probable shape of the solubility-temperature curve of the substance with which he is concerned, the data in the handbook may prove worthless because the solubility is given at 0°C. and 100°C., or even at some such freak temperature as 79° or 3°, when he wishes it at room temperature.

Furthermore, an examination of successive editions of such handbooks often reveals changes so shocking as to undermine one's belief in most printed data of this kind. Many chemists commonly assume that if any such data are to be put to a serious use they must be determined anew for the occasion.

It is a reasonable assumption that the major reasons for the unsatisfactory condition of such tabulations are that making such a measurement appears to be too simple or of too limited interest to justify its inclusion as even a part of a graduate thesis, that there are few other sources of such data, and that there is inadequate machinery for the collection of such measurements as have been made.

Assuming this to be true, may we suggest that such problems be turned over to undergraduate students?

Since many will protest that results so obtained would be unreliable, we further suggest that each problem be pursued by at least two students, independent of and unknown to each other.

This would be made possible by the establishment of a central correlating committee. If such a committee were appointed and sponsored by the American Chemical Society, it would act as a national clearing house for problems and results. Practicing chemists and chemistry teachers would be asked to suggest problems to the committee and these would be assigned individually to students requesting problems, in many cases to those working under the persons making the original suggestions. Certainly the committee would be expected to act merely as a correlating agency, suggesting problems only upon request and not attempting to dictate national research policies.

Many teachers, harassed by the need to stimulate A and B grade students in courses necessarily designed for C students, would find the problems suggested by the committee a source of ample motivation. Such nationally sponsored junior research should help those schools which are dissatisfied with the results now obtained in undergraduate research.

Obviously, it would be impossible for the committee to publish individual papers on each problem, but a summation of the results accepted could be published in some journal of the Society, along with a mention of the names of the contributors. Publishing the names of the students contributing each accepted result would give a great stimulus to elementary research, just as the publication of papers and the recognition of one's fellows is the major motivation for most of the advanced research now being done.

As a further motivation we suggest that a certificate be awarded to each student who contributes a result that proves to be valid by the test of independent checking. The certificate might bear some such legend as "The American Chemical Society is pleased to accept your data on the temperature-solubility curve of nickel acetate." May we remind those who doubt the importance an undergraduate would attach to such a certificate that millions of adult Americans toil over lodge rituals to attain some such title as the Exalted Night Hawk, that thousands of housewives devise recipes in the hope of winning certificates of approval from certain household magazines, and that many Boy Scouts work very hard for merit badges.

Such a certificate of approval from the American Chemical Society might lead many an undergraduate, undecided as to his career, to choose our profession. Started upon a career in chemistry by the stimulus of national recognition, he would hardly fail to continue to have an active interest in research, and to become a loyal member of the Society.

CRYSTAL CHEMISTRY

IV. THE STRUCTURE OF BINARY COMPOUNDS. THE AX_2, A_2X_3, AX_3, AX_4 COMPOUNDS. SUMMARY

CHARLES W. STILLWELL

Dennison Manufacturing Company, Framingham, Massachusetts

THE STRUCTURES OF AX_2 COMPOUNDS

LIKE compounds of the general formula AX, the AX_2 compounds may be formed with ionic, covalent, or molecular forces, and the structures of these compounds are determined by the relative sizes and the polarization properties of their building stones. It is helpful to mark the AX_2 regions on the chart.* There are three main groups: one, at the left, running diagonally downward from left to right, includes the AX_2 compounds of ions with the rare gas configuration. A second, past the center and also running downward from left to right, contains compounds in which the cation has a completed eighteen-electron shell. A third, zone VII, includes the transition elements, those with incomplete eighteen-electron shells.

There is every reason to believe that these three types of cations will exert, in general, the same polarization influences in AX_2 compounds as they do in AX compounds. It may be predicted that the A cations will form ionic crystals whose structures will be determined largely by relative ionic sizes; B cations will tend to form covalent or semi-ionic bonds; while the transition elements will form crystals resembling in properties those with the NiAs structure. They will not, of course, crystallize in the NiAs lattice, since the relative numbers of atoms are different in the two.

Three general structural types of AX_2 compounds are conceivable:

1. A and X are individual building stones, giving rise to ionic or atomic lattices, such as the CaF_2, TiO_2, CdI_2, MoS_2, $CdCl_2$ structures.
2. The building stones are A and X_2, or A and XY as in the CaC_2, FeS_2 and KCN structures.
3. The building stones are molecules of AX_2, as in CO_2 and N_2O. The unit cells of these several structural types are shown in Figure 5.

The Transition $CaF_2 \rightarrow TiO_2$ (Rutile).—This transition involves a change in coördination number from 8(4) for fluorite to 6(3) for rutile, and it has already been shown that, for the difluorides of all three types of ion, the change in structure is closely related to the ionic sizes. The same relation holds generally for the dioxides of a number of tetravalent elements, as may be seen from the data in Table 16. The fluorite and rutile lattices are limited almost entirely to the fluorides and oxides. In these structures the building stones are practically undistorted spheres. For packing of spheres, it is required that the axial ratio of the TiO_2 lattice be 0.72. Actually, the axial ratios of nearly all the com-

* Figure 1, this series, first instalment: J. CHEM. EDUC., 13, 415–9 (1936).

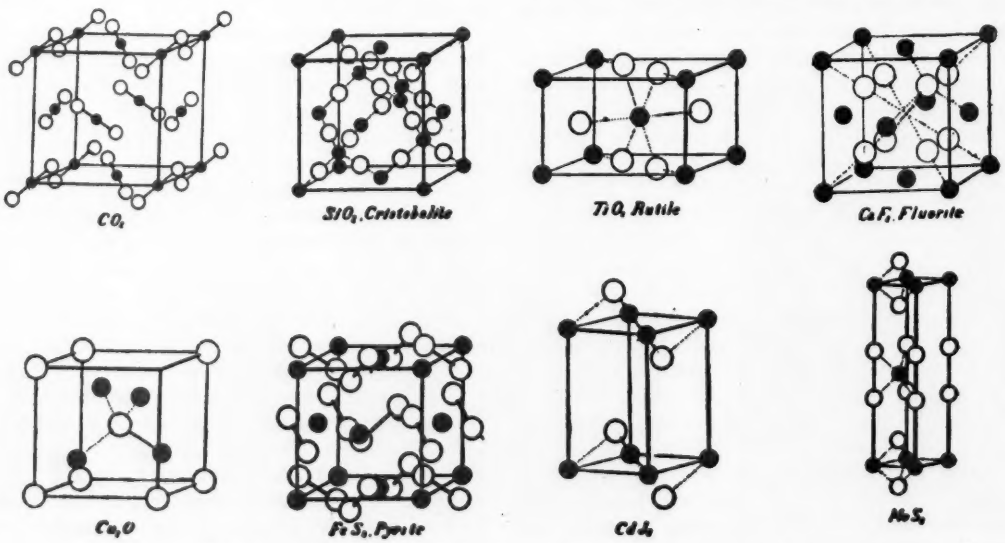

FIGURE 5.—SOME IMPORTANT STRUCTURE TYPES OF COMPOUNDS AX_2

pounds known to crystallize in this lattice lie between 0.60 and 0.70. In the exceptions it may be assumed that the ions are distorted, and since the interionic distances agree very well with the values for ionic radii, the bonds are undoubtedly essentially ionic. It has been shown (*56*) that the Coulomb energy of the fluorite structure is lower than that of the rutile structure, suggesting that all ionic AX_2 compounds should crystallize like fluorite. This structure has the highest degree of symmetry of all the AX_2 types. It is evident, however, that the geometric influence is strong enough to cause the fluorite → rutile transition when the $R_A:R_X$ ratio decreases below *ca.* 0.67, which is significantly close to the value 0.73 at which, for the packing of perfect spheres, the coördination number will change from eight to six.

TABLE 16

THE STRUCTURE OF DIFLUORIDES AND DIOXIDES AS RELATED TO $R_A:R_X$ RATIOS

	MnO_2	VO_2	TiO_2	RuO_2	IrO_2	OsO_2						
R_A/R_X	.39	.43	.45	.45	.49	.49						
	SnO_2	CbO_2	MoO_2	WO_2	PbO_2	TeO_2	ZrO_2	HfO_2	PrO_2	CeO_2	UO_2	ThO_2
R_A/R_X	.49	.50	.51	.51	.53	.63	.66	.65	.75	.76	.79	.83
	MgF_2	NiF_2	CoF_2	FeF_2	MnF_2	ZnF_2	$SrCl_2$	CdF_2	CaF_2	SrF_2	PbF_2	BaF_2
R_A/R_X	.56	.56	.59	.60	.62	.62	.66	.75	.79	.89	.89	1.04
	Rutile Structure C.N. = 6 − 3						Fluorite Structure C.N. = 8 − 4					

In addition to the difluorides and dioxides (also $SrCl_2$ and US_2), the following compounds crystallize in these ionic lattices: Cu_2S, Cu_2Se, Li_2O, Li_2S, Na_2S; Mg_2Pb, Mg_2Si, Mg_2Sn. It is very probable that the bonds in these A_2X compounds are also ionic. With two univalent polarizing cations to each easily polarized anion ($S^=$ or $Se^=$) no one cation can exert as strong a distorting effect upon its neighboring anion as would be the case in a crystal of divalent cations and univalent anions, in true AX_2 compounds.

The Transition TiO_2 → SiO_2.—This transition, involving a decrease in coördination number from 6(3) to 4(2), results when the $R_A:R_X$ ratio falls below the critical value 0.41. While the large oxygen ions are not close-packed in any of the several different forms of SiO_2, the high temperature forms, tridymite and cristobalite, are open structures, maintained by thermal agitation; while quartz, stable at ordinary temperatures, is a somewhat more close-packed arrangement. These open structures may also be stabilized by the inclusion of impurities (*57*). In each the silicon ions or atoms lie at the centers of oxygen tetrahedra. As is now well known, however, this tetrahedral coördination will permit either ionic or covalent bonds, and the type of bond actually present must be determined from other considerations. An ionic structure would allow the oxygen bonds to assume any angles, while covalent bonds should approximate angles of 90° or 109.5°. In beta-tridymite the observed angle of 180° suggests an ionic bond, while in alpha-quartz the bonds may be predominantly covalent. GeO_2 has the structure of alpha-quartz.

The number of truly ionic crystals is more limited among the AX_2 compounds than within the AX group. This is not strange, since a divalent cation is less easily ionized and is also known to exert a stronger polarizing influence on a given anion than does a univalent cation of the same size. The influence of this stronger polarization is illustrated in Table 17.

TABLE 17

INFLUENCE OF POLARIZATION ON AX AND AX_2 STRUCTURES

	AX Structures				*AX_2 Structures*			
Anion / Anion Radii	O 1.43 Å.	S 1.82	Se 1.93	Te 2.12	F 1.33	Cl 1.80	Br 1.96	I 2.20
Cation Radii								
Mg .83 Å.	NaCl	NaCl	NaCl	ZnO	TiO_2	$CdCl_2$	CdI_2	
Mn .83	NaCl	NaCl	NaCl	NiAs	TiO_2	$CdCl_2$	CdI_2	CdI_2
					AX Structures			
Li .68					NaCl	NaCl	NaCl	NaCl
Na 1.00					NaCl	NaCl	NaCl	NaCl

A horizontal comparison of the AX and AX_2 groups in this table shows the effect of decreasing valence of the anion on polarization and crystal structure, the sizes of the anions remaining the same. In the AX group the structures are ionic (NaCl structure) for the oxides, sulfides, and selenides, while in the AX_2 group only the fluorides are strictly ionic (TiO_2, rutile structure). The $CdCl_2$ and CdI_2 structures are the result of strong polarization. That is, chloride, bromide, and iodide ions are much more easily polarized by magnesium and manganese than are sulfide, selenide, and telluride ions. Furthermore, a vertical comparison of the AX and AX_2 groups shows that chloride, bromide, and iodide are more easily polarized by a divalent cation than by a univalent cation of comparable size, since the divalent cation produces a structure which is known to be the result of strong polarization.

The Transition Ionic Lattice → Layer Lattice.—

$$CaF_2,\ TiO_2 \longrightarrow CdCl_2,\ CdI_2,\ MoS_2$$
$$\text{C.N. } 8\text{-}4,\ 6\text{-}3 \longrightarrow 6\text{-}3,\ \ 6\text{-}3,\ \ 6\text{-}3$$

The CdI_2 lattice is formed under the influence of strong polarization. Thus, when the fluoride (radius = 1.33 Å.) in CaF_2 is replaced by the hydroxyl ion, having the same ionic radius but being unsymmetrical and easily polarized, the resulting $Ca(OH)_2$ crystallizes in the CdI_2 structure. This is a so-called layer lattice; the building stones are arranged so that the cadmium ions are coördinated symmetrically to six iodide ions, but each iodide ion has three cadmium neighbors *on only one side.* This means that there are positive and negative ions in the sequence:

$$\begin{array}{ccc} X^- & X^- & X^- \\ A^{++} & A^{++} & A^{++} \\ X^- & X^- & X^- \end{array}$$
$$\begin{array}{ccc} X^- & X^- & X^- \\ A^{++} & A^{++} & A^{++} \\ X^- & X^- & X^- \end{array}$$

an arrangement which gives rise to a discontinuity in strength along the vertical direction, since the bonds between adjacent layers of negative ions must be very weak in comparison with those between ions of opposite charges. A packing drawing of the CdI_2 structure is shown in Figure 6.

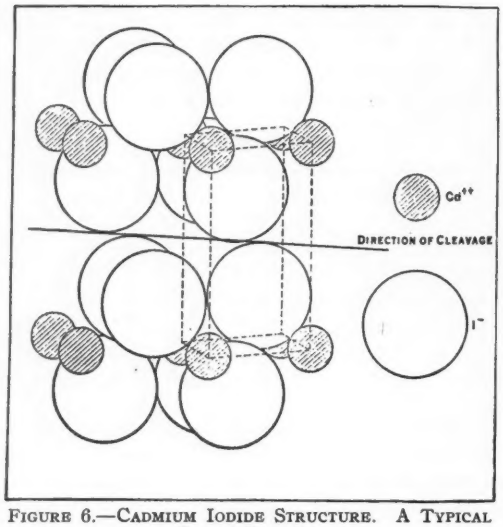

FIGURE 6.—CADMIUM IODIDE STRUCTURE. A TYPICAL LAYER LATTICE

It is convenient to consider the three structures $CdCl_2$, CdI_2, and MoS_2 as a group, since all are of the layer lattice type. The experimental values of the $R_A:R_X$ ratios of the first two of these are compared, in Table 18, with the values found for crystals with the rutile structure.

TABLE 18

RANGE OF EXPERIMENTAL $R_A:R_X$ VALUES OF RUTILE, $CdCl_2$, AND CdI_2 CRYSTALS

TiO_2	.39–.63
$CdCl_2$	.28–.55
CdI_2	.24–.54

Obviously the transition rutile to $CdCl_2(CdI_2)$ cannot be attributed to the relative ionic radii, nor can one predict on the basis of radius ratio which of the structures, rutile, $CdCl_2$, or CdI_2, will occur. On the contrary, a survey of the compounds which crystallize like $CdCI_2$ and CdI_2 makes it plain that these structures are always the result of polarization. Among those compounds there are three distinct groups:

1. The bromides and the iodides of divalent transition ions and B cations, and of the smallest of the A cations, Mg^{++}. These are all strongly polarizing and are combined with the two halides most easily polarized.
2. The sulfides, selenides, and tellurides of some tetravalent ions, including palladium, platinum, tin, titanium, and zirconium, all strongly polarizing cations with easily polarized anions.
3. Hydroxides of many divalent ions, those with the rare gas configuration (Ca, Mg) as well as the B cations (Cd) and transition cations (Co, Fe, Ni, Mn). The OH^- has a permanent dipole and so induces the formation of the CdI_2 structure even when combined with a cation such as calcium, which is not strongly polarizing.

The relationship of the CaF_2, rutile, $CdCl_2$, and CdI_2 structures may be seen more clearly in Table 19. It is evident that the rutile structure is not an intermediate type in the transition from $CaF_2 \longrightarrow \left\{ \begin{matrix} CdCl_2 \\ CdI_2 \end{matrix} \right\}$. The occurrence of the CaF_2 or rutile structure is a matter of ionic radii. The substitution in either of these lattices, of an easily polarized ion for one which does not polarize easily, leads to the $CdCl_2$ or CdI_2 structure.

The $CdCl_2$ structure, on the other hand, is obviously a "halfway point" in the transition $\left\{ \begin{matrix} CaF_2 \\ TiO_2 \end{matrix} \right\} \rightarrow CdCl_2 \longrightarrow CdI_2$, and is therefore produced when the degree of polarization is greater than in the CaF_2 or rutile lattice but less than in the CdI_2 lattice. This $CdCl_2$ lattice is found only among chlorides of certain divalent cations of all three types: the rare gas cations (Mg), ions of the transition elements (Mn, Fe, Co, Ni, Ru, Rh, Pd, Ir, Pt) and divalent B cations (Zn, Cd).

TABLE 19

OCCURRENCE OF THE $CdCl_2$ AND CdI_2 STRUCTURES

Cation	*Radii*	*Anion* F	Cl	Br	I
Ni	.74 Å.	TiO_2	$CdCl_2$		
Co	.78	TiO_2	$CdCl_2$	CdI_2	CdI_2
Fe	.80	TiO_2	$CdCl_2$	CdI_2	CdI_2
Mn	.83	TiO_2	$CdCl_2$	CdI_2	CdI_2
Zn	.83	TiO_2	$CdCl_2$		
Mg	.83	TiO_2	$CdCl_2$	CdI_2	
Cd	.99	TiO_2	$CdCl_2$	$CdCl_2$	CdI_2
Ca	1.05	CaF_2			
Sr	1.18	CaF_2	CaF_2		
Ba	1.38	CaF_2			

The $CdCl_2$ and CdI_2 structures are very similar. They have been described in detail by Pauling and Hoard (*58*, *59*). In both, each cadmium ion is surrounded octahedrally by six halogen ions and the edges of these octahedra are shared with others to form a complete octahedral layer. In the CdI_2 structure the layers are superimposed so that each cation is directly above a cation in the layer below, while in the $CdCl_2$ structure each cation is directly above an anion in the layer below. This arrangement within the layers is shown schematically below.

$CdCl_2$ Structure		*CdI_2 Structure*	
Cl at A	↑	I at A	↑
Cd at B		Cd at B	Length of Unit
Cl at C		I at C	
Cl at B		I at A	↓
Cd at C	Length of Unit	Cd at B	
Cl at A		I at C	
Cl at C		I at A	
Cd at A		Cd at B	
Cl at B		I at C	
Cl at A		I at A	
Cd at B	↓	Cd at B	
Cl at C		I at C	

Evidently there is no essential physical difference in these two arrangements, merely a difference in the sequence of layers and therefore in the unit of structure. In fact, although sublimed $CdBr_2$ has the $CdCl_2$ structure, it has recently been claimed (*60*) that the diffraction pattern of precipitated $CdBr_2$ shows only the lines common to both the $CdCl_2$ and CdI_2 structures, and a structure is suggested in which there is a random arrangement of the layers of both types.

The nature of the bonds in crystals of the $CdCl_2$ and CdI_2 types may be surmised from a consideration of interionic distances. In both, the anion-anion distances are compatible with ionic radii. The Cd-Cl distance in $CdCl_2$, however, is only 2.66 Å. as compared with 2.78 Å., the sum of the ionic radii. This decrease in interionic distance is partly the result of polarization. From the standpoint of bond type, both these structures are transitional in nature. The bonds within a given layer are semi-ionic; each layer may represent a single giant molecule. The bonds between layers are weaker, essentially molecular or van der Waals forces. In the comparable AX compounds, those with the ZnS (ZnO) structure, a layer lattice is not possible and strong covalent or semi-ionic bonds extend throughout the crystal, so that the whole may be thought of as a giant molecule.

Whereas in the $CdCl_2$ and CdI_2 layer lattices the halogen ions are at the corners of an octahedron, only slightly distorted, in the MoS_2 lattice the negative atoms are at the corners of a trigonal prism, as shown in Figure 5. Furthermore, the S-S distance indicates that the sulfurs are in the atomic rather than the ionic state (*61*). The MoS_2 structure is a layer lattice built of atoms in which the forces are largely covalent within layers. It is known only for WS_2, WTe_2, MoS_2, $MoSe_2$, and $MoTe_2$.

The Transition (CdI_2, $CdCl_2$, MoS_2) $\longrightarrow$ FeS_2.—The pyrite structure is found among compounds of the transition elements with S, Se, Te, P, As, Sb; the same combinations of elements which, in AX compounds, form the NiAs lattice. The properties of compounds crystallizing in the pyrite lattice are distinctive and similar to those of compounds with the NiAs structure.

The difference between the layer lattices and that of pyrite seems to depend primarily upon the condition of the X atoms in the compound AX_2. In the $CdCl_2$ and CdI_2 lattices X is an ion, or nearly so; in the MoS_2 lattice are found X atoms, while, as may be seen from Figure 5, in pyrite there exists in the lattice a definite X_2 molecular group. The distance Fe-S in the pyrite crystal indicates that the iron is in the atomic rather than the ionic state and the Fe-S bond is probably predominantly covalent. The S-S distance is 2.08 Å. (*62*), as compared with a S-S distance of 1.81 Å. in gaseous sulfur (S_2).

It is interesting to consider the cause of these differences in the condition of the X atoms. Goldschmidt has suggested that when the atomic radii of the metals are large, layer lattices are formed; whereas metals with small radii and low valences cannot split the X_2 molecule, and the pyrite lattice results. This suggestion is based on his classification (*62*), shown in Table 20.

The influence of the valence of the metal, however, appears to be of greater significance than the size. Those metals which form the CdI_2 or MoS_2 structure are all quadrivalent, and each may therefore combine with two X atoms, either through ionic bonds (in CdI_2) or covalent bonds (in MoS_2). Those metals which

TABLE 20

ATOMIC RADII AND THE OCCURRENCE OF THE FeS_2 STRUCTURE

ELEMENT	RADIUS (*C.N. 12*)	STRUCTURE OF SULFIDES, SELENIDES, TELLURIDES *Compounds*			*Structure Type*
Zr	1.60	ZrS_2	$ZrSe_2$		CdI_2
Sn	1.58	SnS_2			CdI_2
Ti	1.45	TiS_2	$TiSe_2$	$TiTe_2$	CdI_2
W	1.41	WS_2	WSe_2	WTe_2	MoS_2
Mo	1.40	MoS_2	$MoSe_2$	$MoTe_2$	MoS_2
Pt	1.38	PtS_2	$PtSe_2$	$PtTe_2$	CdI_2
Pd	1.37			$PdTe_2$	CdI_2
Mn	1.38	MnS_2		$MnTe_2$	FeS_2
Os	1.34	OsS_2	$OsSe_2$	$OsTe_2$	FeS_2
Ru	1.32	RuS_2	$RuSe_2$	$RuTe_2$	FeS_2
Fe	1.27	FeS_2			FeS_2
Co	1.26	CoS_2	$CoSe_2$		FeS_2
Ni	1.24	NiS_2	$NiSe_2$		FeS_2

favor the pyrite structure, on the other hand, are apt to form divalent ions. They are therefore unable to combine with two separate divalent X atoms either through ionic or covalent bonds. But when two divalent X atoms combine with themselves to form an X_2 group, the electronic arrangement may be presumed to be $:\ddot{X}:\ddot{X}:$, leaving two electrons lacking to complete the octets. The X_2 group, then, may be considered as having a negative valence of two, and is equivalent in combining power to one divalent X atom. The divalent metals are therefore able to combine with this X_2 group just as they can combine with a single divalent negative atom. Hence the type of combination may be essentially the same in FeS and in FeS_2, both satisfying the same valence requirements. That the type of bond is similar in crystals of the NiAs and FeS_2 types is unmistakably supported by the striking similarity of properties of these two groups. The situation may be summarized in slightly different terms. A tetravalent metal atom can and does hold each divalent X atom separately; a divalent metal atom cannot do this and, as an alternative, holds one divalent X_2 group.

As further evidence in support of this picture, the comparisons in Table 21 may be cited (Goldschmidt, *loc. cit.*).

TABLE 21

STRUCTURES OF CERTAIN PLATINUM SALTS

CdI_2 Structure	*FeS_2 Structure*
PtS_2	PtP_2
$PtSe_2$	$PtAs_2$
$PtTe_2$	$PtSb_2$

Let it be assumed that the platinum tends to be quadrivalent. Then it is able to hold two divalent X atoms separately and the sulfide, selenide, and telluride of platinum crystallize in the CdI_2 structure. But two trivalent atoms (*e. g.*, P, As, Sb) cannot be held separately by a tetravalent atom. When two trivalent atoms X form an X_2 group, however, the electronic arrangement is $\overset{\times\times}{\underset{\times\times}{X}}\!\!-\!\!\overset{--}{\underset{--}{X}}$, and the group lacks four electrons to complete the octets. That is, the X_2 group, as such, has a negative valence of four, and can combine with tetravalent platinum in the usual way. Stated in another way, platinum has a high enough valence to

split the S_2 group, but not the P_2 group. One may predict that in an AX_2 compound with X trivalent, if A were hexavalent, the compound would have the CdI_2 or MoS_2 structure.

Of course, it must be emphasized that all the bonds in the FeS_2 structure are not strictly covalent. The pronounced metallic properties of compounds with this structure indicate that some bonds are, to some degree, metallic. It is probably significant that in both the NiAs and FeS_2 structures the metal is always a transition element. In CoS_2 and NiS_2, for example, there are electrons which cannot be placed in the regular 3d, 4s, and 4p orbitals but must go into excited orbitals. These are probably metallic electrons (*63*).

The CaC_2 Structure.—This structure bears a certain resemblance to pyrite in that the carbon atoms exist as C_2 groups. The resemblance ceases here, however, for the properties of the carbides do not resemble those of the pyrite group in the least. It will be recalled that the carbides of the transition elements are interstitial structures. The CaC_2 structure has been observed for the carbides of Ca, Sr, Ba, Ce, La, Nd, Pr.

The Transition $FeS_2 \longrightarrow CO_2$.—In both these structures the space group and the atomic positions are the same, but the parameters are different.

Both structures may be thought of as special cases of the NaCl structure. In all three, the atoms A are on a face-centered cubic lattice. In NaCl the atoms X are on an interpenetrating face-centered cubic lattice; in pyrite, X_2 groups are on an interpenetrating, face-centered cubic lattice; in CO_2, the X atoms have moved toward the X atoms, given up their independence, and become part of the CO_2 molecule. The KCN lattice may also be considered as an elaboration of the NaCl structure (Wyckoff, *op. cit.*, pp. 234–5). In this case the CN^- ion acts as a unit, so that the compound KCN belongs more properly with AX compounds than with the AX_2 group.

In AX_2 compounds, therefore, the complete transition from an ionic to a molecular lattice might be represented by the series

CaF_2 TiO_2	$\longrightarrow$	$CdCl_2$ CdI_2	$\longrightarrow$	CO_2
Ionic	$\longrightarrow$	semi-ionic in layers; molecular between layers	$\longrightarrow$	covalent C—O bonds; molecular between molecules.

The stabilities of different lattices, based on lattice energies, have been calculated for AX_2 compounds (*64*). It has been shown that, as the polarizability, α, increases and the radius of the cation, r, decreases, the resulting lattice energies favor the stability of a molecular rather than an ionic lattice. This relationship, for AX_2 compounds, is shown in Figure 7. It is evident from the figure that the layer lattice is an intermediate stage in the transition from an ionic to a molecular lattice and becomes stable at a much smaller value of α/r^3 than does the molecular lattice. What is more, the stability ranges of the CaF_2 and rutile lattices are limited to very small values of α/r^3 and, as has already

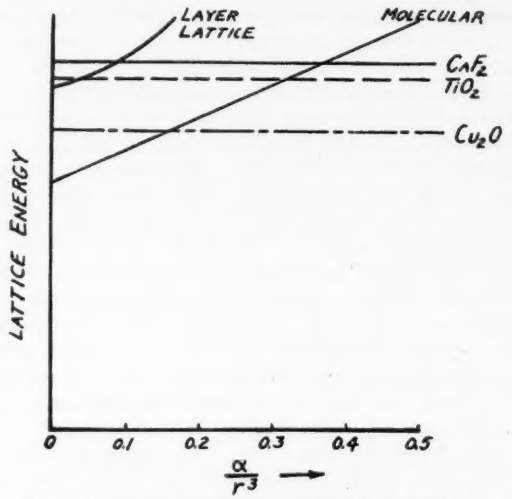

FIGURE 7.—RELATION OF LATTICE ENERGY OF AX_2 TYPE CRYSTALS TO POLARIZABILITY (α) AND CATION RADIUS (r) (BORN AND BOLLNOW)

been observed, these structures are found mainly for fluorides and oxides, for which α is very small. Only carbon is small enough to form a molecular AX_2 lattice, so that CO_2 is the only molecular crystal of this group.

SUMMARY OF THE STRUCTURE OF AX_2 COMPOUNDS

The influence of relative sizes and polarization properties on the structure of AX_2 compounds has been summarized graphically by Goldschmidt as shown in Figure 8.

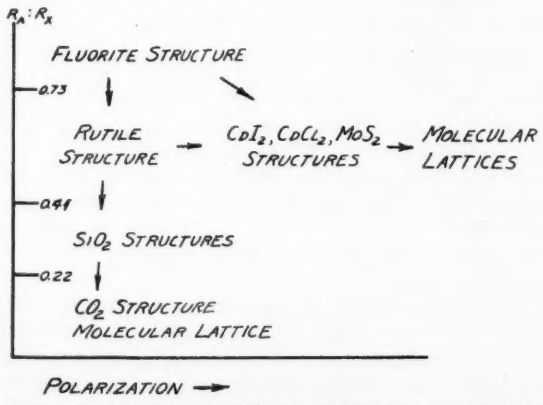

FIGURE 8.—RELATION OF AX_2 STRUCTURES TO POLARIZATION (GOLDSCHMIDT)

Niggli (*65*) has pointed out certain simple but helpful geometric relationships between the arrangement of atoms in metallic, AX, and AX_2 lattices. It is useful to observe that, in general, three principal types of packing may be followed through the most common metallic, AX, and AX_2 structures. These are face-centered cubic, body-centered cubic, and close-packed

hexagonal. In the structures listed in Table 22 it is usually the negative ions or atoms (X), those which Laves has called the "lattice supporters," which are packed in one of these three ways. [For CaF_2, FeS_2, Cu_2O, and CO_2 it is the positive ions or atoms (A) which are on a face-centered cubic lattice.]

TABLE 22

PACKING OF "LATTICE SUPPORTERS" IN METALLIC, AX, AND AX_2 LATTICES

	Body-centered Cubic	*Face-centered Cubic*	*Close-packed Hexagonal*	*Layer*
Metal	Tungsten	Copper	Magnesium	Graphite
AX	CsCl	NaCl ZnS	NiAs ZnO	BN
AX_2		CaF_2 $CdCl_2$ FeS_2 CO_2 Cu_2O	CdI_2 HgI_2	

For a detailed discussion of these geometric relations, see NIGGLI AND BRANDENBERGER, *loc. cit.*; and F. LAVES (*45*).

The relations between relative sizes and polarization properties of ions or atoms and the structures of AX_2 compounds are summarized briefly in Table 23.

which the edges are shortened, a shortening which is quite characteristic of ionic crystals (*67*). The interionic distances also suggest that the bonds are essentially ionic. It is of interest to note in passing that the octahedra are less distorted in Fe_2O_3 than in Al_2O_3. This is consistent with the assumption that the ferric ion, being of about the same volume as the Al^{+++} ion, but containing 23 electrons, is less subject to polarization than is Al^{+++}.

The C-modification of the Rare Earths.—This structure bears an interesting geometrical relation to zincblende and fluorite. It is cubic, and the metal atoms may be pictured on a face-centered cubic lattice as they are in ZnS and CaF_2. In CaF_2, there are eight X ions at the corners of a cube within the face-centered cube of metal ions (see Figure 5); in ZnS, four of these eight X ions have been removed; in the idealized Tl_2O_3 lattice, only two of the eight X ions need be removed to satisfy the stoichiometric relation A_2X_3. In the actual Tl_2O_3 structure there is considerable distortion and the coördinated octahedra are such that the anions lie nearly at six corners of a cube. It is thus possible to maintain the coördination number six even though the $R_A:R_X$ value may be as high as 0.86.

TABLE 23

THE INFLUENCE OF THE SIZE AND POLARIZATION PROPERTIES OF THE BUILDING STONES UPON THE STRUCTURES OF AX_2 COMPOUNDS

Lattice Type	*$R_A:R_X$ Ratio*	*C.N.*	*Polarization*	*Prevalent Bond Type*	*Remarks*
CaF_2	.73	8–4	a minimum	ionic	A = any divalent or quadrivalent cation
TiO_2	.41–.73	6–3	a minimum	ionic	X = fluoride or oxide
					A_2X, X = S or Se
$CdCl_2$, CdI_2 (layer lattice)		6–3	moderate to strong	covalent or semi-ionic within layer Mol. between layers	A = Mg, B-cation, trans. ion $CdCl_2.X$ = chloride $CdI_2.X$ = Br, I, S, Se, Te, (OH) A may be A-cation when X = (OH)
MoS_2 (layer lattice)		6–3	moderate to strong	covalent	A = Mo, W X = S, Se, Te
FeS_2		6–3	moderate to strong	covalent metallic	A = transition element X = S, Se, Te, P, As, Sb
SiO_2, Cu_2O	.22–.41	4–2	moderate to strong	semi-ionic covalent	
CO_2	.15	2–1	strong	covalent (intramolecular) molecular (intermolecular)	

THE STRUCTURES OF A_2X_3 COMPOUNDS

Nearly all the A_2X_3 compounds whose structures have been studied are oxides. Inasmuch as the oxide ion is not easily polarized, the crystals of A_2X_3 compounds are essentially ionic and their structures depend upon the relative sizes of the ions, as is evident from the data in Table 24.

TABLE 24

INFLUENCE OF $R_A:R_X$ ON THE STRUCTURE OF A_2X_3 OXIDES

$R_A:R_X$	*Structure*	*C.N.*	*Examples*
0.43–0.52	Corundum	6–4	α-Al_2O_3, α-Ga_2O_3, α-Fe_2O_3, Ti_2O_3, Cr_2O_3, V_2O_3, Rh_2O_3.
0.53–0.86	C—structure of rare earth oxides	6–4	$(Fe,Mn)_2O_3$, Sc_2O_3, In_2O_3, Cp_2O_3, Yb_2O_3, Tu_2O_3, Er_2O_3, Tl_2O_3, Ho_2O_3, Y_2O_3, Dy_2O_3, Tb_2O_3, Gd_2O_3, Eu_2O_3, Sm_2O_3.
	B—rare earths		Dy_2O_3, Tb_2O_3.
0.86–0.92	A—rare earths	3–2	La_2O_3, Ce_2O_3, Pr_2O_3, Nd_2O_3, Sm_2O_3.

The $R_A:R_X$ values are calculated from the crystal ionic radii, not from the univalent radii.

The Corundum Structure (*66*).—The structure is rhombohedral. As might be expected from the $R_A:R_X$ ratio, each metal ion is surrounded by six oxide ions at the corners of a somewhat distorted octahedron, in

The A-modification of the Rare Earths. La_2O_3.—This is a layer lattice. The name "anti-layer" lattice has been proposed by Goldschmidt, who suggests that the metal cations are polarized by the small oxide ions. Pauling has observed, however, that the molecular refraction of La^{+++} indicates that its polarization is small, and he suggests that the deformation of the lattice is due to the mutual repulsion of La^{+++} ions in a close-packed layer. Because of this mutual repulsion and the resulting deformation, each cation is closer to one anion of another layer than it is to three of the anions in its own octahedra. Actually, each cation is coördinated to seven anions and the crystal is built of electrically neutral double layers of octahedra. Interionic distances indicate that the forces within the layers are essentially ionic.

As_4O_6 and Sb_4O_6 form molecular crystals, the As_4O_6 molecules being distributed in a cubic lattice with their centers at the positions occupied by carbon atoms in the diamond lattice.

A transition from ionic, to layer, to molecular lattice

is illustrated by the series:

$$\text{Corundum} \atop \text{B-mod.} \longrightarrow \text{A-mod.} \longrightarrow As_4O_6$$

THE STRUCTURES OF AX_3 COMPOUNDS

Three main types of AX_3 crystals, reminiscent of the three types of AX_2 crystals, are to be expected (*68*).

$$\begin{matrix} X & X \\ & A \\ & X \end{matrix}$$

1. , in which atoms or ions of A and X act as independent building units in the crystal. Examples: AlF_3 and AsI_3 structures.
2. $A(X)_3$ or $A(XY_2)$, in which the X_3 or XY_2 group is a single unit in the structure. Examples: NaN_3, KN_3, and the isomorphous $CsCl_2I$, $NaHF_2$, and KHF_2.
3. Molecular crystals, in which the AX_3 molecule acts as a structural unit. Example: NH_3.

Neuburger has pointed out (*69*) that those fluorides of trivalent metals, the oxides of which have the corundum structure, crystallize like AlF_3; when the oxides have the C-modification structure, the fluorides crystallize like tysonite. The $R_A:R_X$ values separating these structural types correspond to those for the A_2X_3 groups, since the radii of $O^=$ and F^- are about the same.

Because the fluoride ion is so small, and not easily polarized, the trifluorides do not crystallize in lattices in which the layers are well developed. Layer lattices are to be expected for trichlorides, tribromides, and triiodides, however, in which the anion is easily polarized and larger (*70*). A typical transition from an ionic lattice to a layer lattice (in which the forces within the layer are probably semi-ionic) is represented by $BiF_3 \longrightarrow BiI_3$.

The NaN_3 and KN_3 Structures.—These structures resemble, geometrically, those of pyrite and CaC_2, in that the N_3 group exists in the crystal as such. It is, perhaps, easiest to visualize these structures as they are related to the CsCl and NaCl lattices, respectively (*71*). The substitution of cylindrical N_3 ions for spherical Cl ions causes the NaCl structure to expand along the 111 (body diagonal) direction. It is interesting also to recall the effect of the substitution of a disc-shaped CO_3 ion for Cl ion in the NaCl structure. The lattice is distorted to produce the rhombohedral calcite lattice. The substitution of N_3 ions for Cl ions in the CsCl structure requires an expansion along both the *h* and *k* axes and a tetragonal crystal results.

It is not surprising to find KCNO essentially, though not exactly, isomorphous with KN_3, for the total number of electrons of the two groups CNO and N_3 are the same, each containing three nuclei, six inner, and sixteen outer electrons. Furthermore, the acid fluoride $NaHF_2$ and KHF_2 also crystallize like KN_3, and the HF_2 group has three nuclei and 22 electrons. Other groups which have three nuclei and 22 electrons are CO_2 and N_2O, and these have structures analogous to the N_3 ion—the three atoms are colinear. It is to be expected that the BO_2^- and $BeO_2^=$ and NO_2^+ ions, all with 22 electrons, will also have this colinear structure.

THE STRUCTURES OF AX_4 COMPOUNDS

There is little chance for compounds of this type to crystallize in any but a molecular lattice. This is evident, since each A may be completely surrounded and screened by four X atoms, preventing any direct bond between this A atom and an X atom of a neighboring molecule. The SnI_4 structure is the best known of this group, the building unit being the SnI_4 molecule, of which there are eight in a unit cell. The distance between iodide atoms in neighboring tetrahedra is 4.21 Å., agreeing with their separation in the CdI_2 structure and in molecular iodine. Of the few AX_4 compounds whose structures have been studied, nearly all crystallize like SnI_4.

THE STRUCTURES OF AX_6 COMPOUNDS

It has recently been shown that CaB_6 and a number of isomorphous substances have the CsCl structure, the B_6 octahedra taking the place of Cl ions in this structure (*72*). The structure is difficult to explain on the basis of either ionic or covalent forces.

BINARY COMPOUNDS OF VARIABLE COMPOSITION. SUBTRACTION AND ADDITION COMPOUNDS

The solution of excess sulfur, selenium, and oxygen in the FeS, FeSe, and FeO lattices, respectively, has already been described. Many additional cases of this type of variable composition are coming to light and contribute to the lengthening list of compounds which do not, in the strict sense, conform to the Law of Definite Proportions.

Magnetic ferric oxide, gamma-Fe_2O_3, formed by the low temperature oxidation of Fe_3O_4, retains the spinel structure of the latter. The oxygen lattice remains intact throughout the change, but as the valence of iron increases, vacant positions appear in the iron lattice (*73*). The influence of solid solution in binary compounds upon the electronic conductivity of such compounds has been discussed by Wagner (*74*). According to his interpretation the increasing electronic conductivity of CdO and ZnO with decreasing oxygen pressure (*75*) shows that these oxides can dissolve excess metal: while the increase in electronic conductivity with increasing pressure of iodine and oxygen in CuI (*76*) and Cu_2O (*77*), respectively, indicates the formation of solid solutions with an excess of iodine or oxygen.

Several unusual cases of solid solution, difficult to understand on the basis of the first law of crystal chemistry, are reasonable when viewed in the light of the "subtraction compound"—the crystal with vacant lattice points. $MgCl_2$ and LiCl, although differing in crystal structures and in relative numbers of positive and negative ions, form solid solutions over a wide range of composition (*78*). In both, the chloride ions lie on a close-packed cubic lattice, but in LiCl there are twice as many cations as in $MgCl_2$. Solid solutions of $MgCl_2$ in LiCl, therefore, may be considered as crystals of the LiCl type, but with some of the cation positions vacant. On the contrary, the well-known solid solutions of YF_3

in CaF_2 and of BiF_3 in PbF_2 (*79*) are thought to occur (*80*) because of the interstitial addition of fluoride ions to the CaF_2 lattice, an addition which, because of the relatively small size of F^-, is geometrically possible.

Possibly the isomorphism of $Co(NH_3)_6I_2$ and $Co(NH_3)_6I_3$ is like that of CaF_2 and YF_3 (*81*). In the former case even the large iodide ions may enter the CaF_2 lattice interstitially because of the stable lattice of much larger $Co(NH_3)_6^{++}$ groups.

It is helpful to consider the compounds of variable composition as interstitial phenomena, made possible by the existence of very stable anion lattices. The wide range of homogeneity of the Ag_2HgI_4 lattice (*82*) has been attributed to the stability of the lattice of large, close-packed iodide ions, in the interstices of which small silver and mercuric ions may be substituted more or less indiscriminately.

In many of the silicates interstitial substitution is possible because of the strong SiO_2 skeleton which dominates these crystals.

THE STRUCTURE OF BINARY COMPOUNDS. SUMMARY

In the foregoing pages the First Law of Crystal Chemistry has been developed in detail for binary compounds. The structure of a crystal is determined by the relative numbers, the relative sizes, and the polarization properties of its building stones. The structural details of greatest significance are the arrangement of and the distance between the building stones, and the nature of the bonds between them. It should be recalled that both these criteria have been used in the classification of crystals. Thus, one speaks of the NaCl structure, referring to the arrangement of the building stones; and of the ionic crystal, emphasizing the bond type.

The polarization properties of an atom are determined principally by its size and electronic structure. Valence and the number of electrons in the outer shell of the ion are the important features of electronic structure.

The factors which affect polarization and the methods of measuring this property have been considered at some length. The methods of determining the nature of the bonds in a crystalline solid have been outlined, and the characteristics of the ionic and covalent bonds have been reviewed.

The Effect of Electronic Structure. Polarization Properties.—In summarizing the effect of electronic structure upon polarization and bond type, the ions may be conveniently arranged in three main groups as indicated in Table 25.

TABLE 25

Group	*Electrons in Outer Shell*	*Valence*	*Bond Type*
I. Not strongly polarizing	2	univalent	largely ionic
	8	divalent	
	18 + 2	univalent	
II. Strongly polarizing	2	trivalent	semi-ionic or covalent (except with oxide or fluoride, anions not easily polarized)
	8	tetravalent	
	8 ⟶ 18	transition	
	18		
	18 + 2		
III. Transition ions with S, Se, Te, P, As, Sb, Bi	8 ⟶ 18		partially metallic bond

This classification is borne out by the chart (Figure 1) almost without exception. The regions of two- and eight-electron-shell cations, and the fluorides and oxides contain ionic crystals. The metallic bond region is limited strictly to the sixth, seventh, and eighth group transition elements. Most of the rest are covalent or predominantly covalent compounds with either atoms or molecules for building stones.

The large number of AX and AX_2 compounds which has been studied has made it possible to draw a rather complete picture of the relation of structure of these crystals to the size and polarization properties of their building stones. While the limited number of compounds of the groups A_2X_3, AX_3, AX_4, and AmXn which has been studied does not permit as complete a systematization of types as is possible with the AX and AX_2 groups, certain general tendencies of the entire series of binary compounds may be observed. The influence of the numbers of building stones (as indicated by stoichiometric formulas) and their valences upon the crystal structure of binary compounds, classified according to the character of these building stones, is shown graphically in Figure 9. This chart brings out the following points:

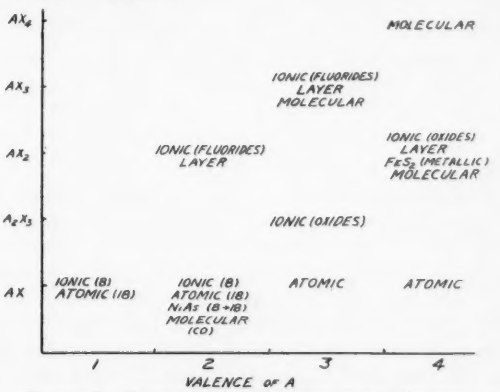

FIGURE 9.—INFLUENCE OF STOICHIOMETRIC FORMULA, VALENCE, AND ELECTRONIC STRUCTURE UPON THE LATTICE TYPE OF BINARY CRYSTALS

1. As the valence of either cation or anion, or both, increases, the tendency to form ionic crystals decreases and the tendency to form molecular crystals increases. In binary compounds, other than the univalent and divalent AX compounds, ionic forces prevail only when the anion is either fluoride or oxide, both highly resistant to polarization. Thus, in the AX and AX_2 compounds, the bonds may be ionic, metallic, covalent, or molecular; and for these compounds the influence of other factors must be taken into consideration.

2. The layer lattice, in which a layer of polarized ions may be thought of as a giant molecule, a structural unit in the crystal, is limited to the AX_3 crystals and the AX_2 compounds in which A is a strongly polarizing cation (also BN). Again, its intermediate position in the transition from ionic to molecular type is evident.

3. Only the molecular lattice is found among AX_4 crystals.

The influence of the relative numbers of building stones, their valences and electronic structures, upon crystal structure is summarized in greater detail in Table 26. Here, both the arrangement of the building units and the nature of the forces holding them together are described.

Some of the more important crystal structures which have been described may be graphically classified, according to the type of bonds holding their building units together, as in Figures 10 and 11. The four principal bond types are typified by NaCl (ionic), diamond (covalent), copper (metallic), and argon (molecular forces).

TABLE 26

Formula	*Valences* A	X	*Electronic Structure*	*Crystal Types (A)*	*Bond Types*
AX	1	1	2, 8, 18 + 2	CsCl, NaCl	Ionic.
			18	ZnS, ZnO, NaCl	Semi-ionic; covalent.
	2	2	2, 8, 18 + 2	NaCl, ZnS, ZnO	Ionic: semi-ionic.
			18	NaCl, ZnS, ZnO	Semi-ionic; covalent.
			8 ⟶ 18	NiAs	Covalent-metallic.
	3	3	2	BN	Covalent-metallic.
			8, 18	NaCl, ZnS, ZnO	Essentially covalent.
	4	4		NaCl, ZnS, ZnO	Essentially covalent.
				CO	Covalent (intramol.). van der Waals (intermol.).
AX_2	2	1	8, 18 (X = F^-)	CaF_2, SnO_2	Ionic.
			8 ⟶ 18 (X = F^-)		
			(8), 18, 8 ⟶ 18	$CdCl_2$, CdI_2 (layers)	Semi-ionic; covalent. van der Waals (between layers).
	4	2	8, 18 (X = $O^=$)	CaF_2, SnO_2	Ionic.
			8 ⟶ 18 (X = $O^=$)		
			8, 18, 8 ⟶ 18	CdI_2	Semi-ionic; covalent. van der Waals (between layers).
			8 ⟶ 18	MoS_2	Covalent (in layers). van der Waals (between layers).
			2	CO_2	Covalent (intramolecular). van der Waals (intermol.).
	?	?	8 ⟶ 18	FeS_2, $FeAs_2$ (S_2 mol. groups)	Covalent-metallic.
A_2X_3	3	2	8, 18, 8 ⟶ 18	Al_2O_3, C-mod., A-mod.	Ionic; semi-ionic. (oxides)
				As_4O_6	Covalent (?) (intramol.). van der Waals (intermol.).
AX_3	3	1		CeF_3	Ionic.
				BiI_3 (layer)	Semi-ionic; molecular.
				NaN_3, KN_3	N_3 ion.
				NH_3	covalent (intramol.). van der Waals (intermol.).
AX_4	4	1		SnI_4	Covalent (intramol.). van der Waals (intermol.).

In the study of the structures of elements, alloys, and binary compounds, four different kinds of bonds have been discussed at considerable length; and it has been observed, in a general way, how they affect the properties of compounds in which they exist. These bonds are: ionic, covalent, metallic, and molecular (van der Waals forces). It has been implied, if not definitely stated, that rarely does a compound occur in which only one pure bond type exists. Some of the alkali halides approach the pure ionic bond; diamond is an example of a crystal in which the building stones are held together by typical covalent bonds; while copper and some of the other metals may be assumed to be characterized by the metallic bond in its purest form. But there are innumerable compounds in which the bond types are mixed. These may be intermediate bond types in the sense in which they usually occur in crystals with the ZnS structure; the bonds are equivalent in all directions, but a bond is intermediate in the sense that it is the average of a polarized ionic component and a covalent component. In the layer lattices and in molecular crystals like SnI_4, the bond types may be said to be mixed, but they are not superimposed; the intramolecular Sn-I bonds are essentially covalent, while the bonds between molecules are weak van der Waals forces. Such compounds cannot be classified by one of the pure bond types; their properties are not characteristic of the ionic, covalent, or metallic bond, but of combinations of these.

On the framework in Figure 10 may be placed the structures with average bond types (as in ZnS, etc.). Figure 11 shows the relationship of structures with two or more coëxistent bond types (as in SnI_4, etc.). The intermediate types are not representative of a gradual transition of bond type within the crystal, but are those in which one type of bond, predominating in two crystallographic directions, coëxists with a second bond type predominating in the third direction. They are the layer and chain lattices. One may observe at a glance the nature of the bonds in any compound which appears on the chart. Thus, the position of AgI indicates that the bonds are semi-ionic; while that of intermetallic compounds is indicative of the metallic-homopolar properties characteristic of the phases. The NiAs structure has metallic properties; and the residue of the attractive forces within this crystal type probably tends toward the covalent.

Structures of elements and of certain complex compounds have been included in these charts as a matter of interest.

There appears to be no logical place on either of these charts for the simple molecular lattice, like CO_2 or SnI_4, in which covalent and van der Waals forces extend between different structural units, but both types are common to all three directions.

The transition, van der Waals ⟶ covalent, in Figure 10 has recently been discussed in a most interesting manner by Glockler and others. The question

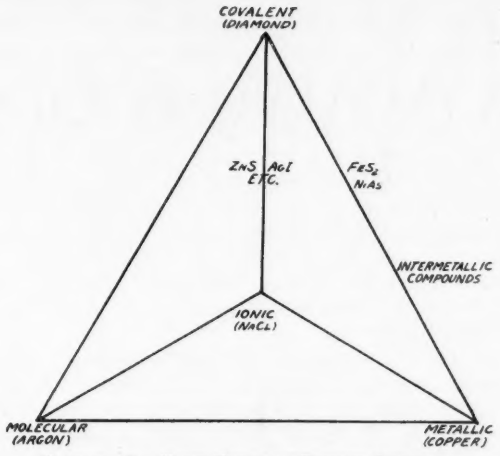

FIGURE 10.—BOND TYPES IN BINARY CRYSTALS

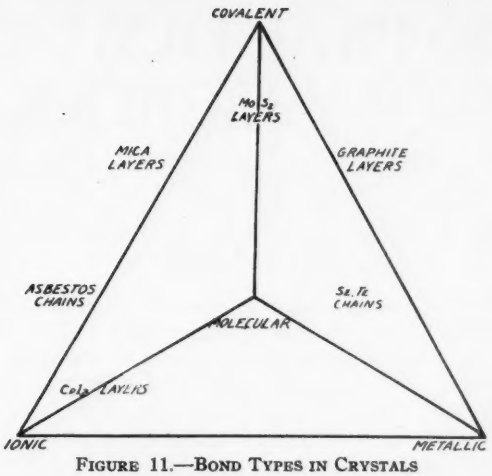

FIGURE 11.—BOND TYPES IN CRYSTALS

has arisen as to whether the association of Kr and HCl should be considered as chemical combination, and the substance Kr-HCl accepted as a true molecule. Commenting upon this, and in answer to a criticism of Hildebrand and Wood (*83*), Glockler points out (*84*) that a molecule is "any configuration of two or more atoms, simple molecules, or radicals which show a potential minimum." This includes coördination compounds* and simple compounds of polar and non-polar types. Glockler suggests that the classification of forces between atoms as covalent, van der Waals, and others is arbitrary and artificial. He visualizes a continuous series of compounds; at one end He-He (van der Waals forces only), at the other extreme H_2 (pure covalent forces). In the middle, one cannot tell whether covalent or van der Waals forces predominate.

* Hunter and Samuel (*85*) have discussed the case of covalent and van der Waals forces in coördination compounds, claiming that in many, such as $AlCl_3 \cdot xNH_3$, KF·HF, and others, van der Waals forces prevail.

It is not justifiable to rule, therefore, that at a certain position in the series molecules cease to exist; rather, the weakly bound complexes should be included as molecules. This view, of course, bears directly upon the long-disputed question as to where, from the standpoint of combining forces, adsorption ceases and compound formation begins. Glockler rules that such associations as Kr-HCl, Ar-KCl and oxygen adsorbed on tungsten should be considered as molecules. Along the line "covalent—molecular," then, in Figure 10, may be placed many adsorption complexes. Others, such as those resulting from preferential adsorption on the faces of ionic crystals, belong along the "ionic—molecular" line.

The crystalline structure of a solid—the arrangement of, and the distance between its building stones and the kinds of forces holding them together—affects profoundly its properties. In the next two sections the properties of binary compounds will be considered in the light of the structures which have been described.

LITERATURE CITED

(56) PAULING, L., *J. Am. Chem. Soc.*, **49**, 784 (1927).
(57) BUERGER, M. J., *Z. Krist.*, **90**, 186 (1935).
(58) PAULING, L., *Proc. Nat. Acad. Sci.*, **15**, 709 (1929).
(59) PAULING, L. AND HOARD, J. L., *Z. Krist.*, **74**, 546–51 (1930).
(60) BIJVOET, J. M. AND NIEUWENKAMP, W., *ibid.*, **86**, 466 (1933).
(61) WYCKOFF, R. W. G., "The structure of crystals," The Chemical Catalog Co., Inc., New York, 2nd ed., **1931**, p. 232.
(62) GOLDSCHMIDT, V. M., *Trans. Faraday Soc.*, **25**, 279 (1929).
(63) PAULING, L. AND HUGGINS, M. L., *Z. Krist.*, **87**, 228 (1934).
(64) Reference 55, page 451.
(65) NIGGLI, P. AND BRANDENBERGER, E., *Z. Krist.*, **79**, 379 (1931).
(66) PAULING, L. AND HENDRICKS, S. B., *J. Am. Chem. Soc.*, **47**, 781 (1925).
(67) WYCKOFF, R. W. G., "The structure of crystals," p. 252. Reference 63, page 216.
(68) NOWACKI, W., *Z. Krist.*, **89**, 85 (1934).
(69) NEUBURGER, M. L., *Sammlung Chem. u. Chem. Tech. Vortrage Ahrens*, **17**, 1 (1933).
(70) MEGAW, H. D., *Z. Krist.*, **87**, 185 (1934).
(71) HENDRICKS, S. B. AND PAULING, L., *J. Am. Chem. Soc.*, **47**, 2904 (1925).
(72) VON STACKELBERG, M., *Z. Elektrochem.*, **37**, 542 (1931).
(73) HAGG, G., *Z. physik. Chem.*, **B29**, 95 (1935).
(74) WAGNER, C., *ibid.*, **B22**, 181 (1933).
(75) BAUMBACH, H. H. V. AND WAGNER, C., *ibid.*, **B22**, 191 (1933).
(76) NAGEL, K. AND WAGNER, C., *ibid.*, **B25**, 71 (1934).
(77) DUNWALD, H. AND WAGNER, C., *ibid.*, **B22**, 212 (1933).
(78) BRUNI, O. AND FERRARI, A., *Z. Krist.*, **89**, 499 (1934).
(79) HASSEL, O. AND NILLSEN, S., *Z. anorg. allgem. Chem.*, **181**, 172 (1929).
(80) HAGG, G., *Z. Krist.*, **91**, 114 (1935).
(81) HASSEL, O. AND KRINGSTAD, H., *Z. anorg. allgem. Chem.*, **209**, 281 (1932).
(82) KETELAAR, J. A. A., *Z. Krist.*, **87**, 436 (1934).
(83) HILDEBRAND, J. H. AND WOOD, S. E., *J. Chem. Physics*, **2**, 822 (1934).
(84) GLOCKLER, G., *ibid.*, **2**, 823 (1934).
(85) HUNTER, R. F. AND SAMUEL, R., *Chemistry and Industry*, **31**, 467 (1935).

The PRACTICAL CARE *of* SCHOOL SWIMMING POOLS

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A description of methods of care of a school swimming pool which have given good results in actual practice, without the necessity of expensive apparatus, materials, or controls. The treatment is based on five simple rules, and may be carried out by anyone who will use care in following the directions, but does not demand any technical training.

Various sterilizing agents are discussed, with the results found by experience as to satisfaction, efficacy of treatment, and expense.

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VARIOUS books and articles dealing with the subject of swimming pool sanitation are available, but in the main these published accounts are concerned with large pools where the traffic is heavy and expensive apparatus is warranted. However, in the care of smaller pools, and especially of school pools where rather rigid rules as to preshowering can be enforced, such equipment is not necessary, provided certain rather simple rules are followed.

During the past five years, it has been a part of the author's duty to supervise the care of the water in a 370,000-gallon pool. At the beginning of that period the pool was being dumped every two weeks, scrubbed, and refilled, the building janitor dumping in a quart or quart and a half of a solution of sodium hypochlorite each morning after vacuum cleaning the bottom of the pool. The city health department started sampling the pool water and reported very erratic results, with a frequent bacterial count which showed a very undesirable condition of the water. No attempt was made to regulate the acidity.

Under the treatment started at that time, the following rather simple rules, which have shown consistently satisfactory results, have been worked out.

(*a*) Vacuum clean the bottom of the pool daily, watching especially for any materials which may have been dropped in the water.

(*b*) Wash the high-water mark off the tiles before adding the fresh water to replace that removed by the suction. This also furnishes an opportunity to clean the scum gutter thoroughly.

(*c*) Refill pool, warming when necessary to maintain a satisfactory water temperature. We have used 72° to 74°F. for our water temperature requirement and 80°F. for the room.

(*d*) Circulate water through a sand filter from six to eight hours during the day and while the pool is in use. Only four times during the five years has it been necessary to use the alum pot which is provided as part of the filter equipment.

(*e*) Daily (and this is important) check the pH of the pool, adding soda ash to correct for any acidity, and at the same time add sodium hypochlorite solution to the water. If the pH of the water is kept between 7.8 and 8.2, no free chlorine is liberated from the hypochlorite, thus avoiding odors in the room and the water, and serving to retain a residual available chlorine content in the water which is not only desirable but also absolutely essential if the water is to remain practically sterile. It is of interest to note that in the spring of the year an odor does develop, caused by the chlorination of phenolic compounds probably coming from surface or swamp drainage in the water supply, but even at this time no *free* chlorine is present.

In actual practice, on a seven-day-a-week treatment, soda ash in the form of two-pound fused bricks is dropped in the pool at the deepest point where the outlet to the filter is located. It usually takes one or two of these bricks each day, the number being regulated by a determination of the pH. If no comparator is at hand, four drops of a 0.5 per cent. solution of phenolphthalein indicator added to a test-tube of the pool water and turning a good clear pink approximates the desired pH. This careful control of the pH is most important, as it allows the retention of residual available chlorine; furthermore, an alkaline medium is unfavorable for the multiplication of many bacteria. This degree of alkalinity, on the other hand, is not hard on the eyes.

If a comparator is at hand, the amount of residual chlorine may also be determined. This should not go below 0.2 p.p.m., nor above 0.5 p.p.m. Less residual chlorine is inadequate for properly protecting the water from pollution, and more results in body and eye irritation. If no comparator is at hand, the problem becomes largely one of try and see what happens. The water from our city supply takes on a beautiful blue color instead of a greenish hue when it is being adequately protected. Potassium iodide, starch, and hydrochloric acid will give the starch-iodide blue if excess hypochlorite is present.

Again, in actual practice, we have found that from two to three quarts per day of a commercial solution of sodium hypochlorite of nine per cent. strength has usually proved adequate, though, of course, in this as in the use of soda ash, the amount needed depends on the extent to which the pool is used.

For a time we tried using calcium hypochlorite. This is a little less expensive and has the advantage of being a dry solid rather than a somewhat corrosive liquid. Its disadvantage lies in the fact that the water is rendered cloudy by the precipitated calcium carbonate which is formed by reaction with the soda ash, and also in the increased hardness of the water.

Finally, by way of warning, too much emphasis cannot be placed on the paramount necessity of being absolutely conscientious in the daily treatment when the pool is in use. Too great residual chlorine content is to be avoided (as previously mentioned) but satisfactory results can only be obtained by being sure that the small safety factor of available free chlorine is indeed ever present. Aside from this daily care in treatment, the other largest contributing agent is one which is controlled by the swimming supervisor—namely, adequate showering, with the use of soap, by the swimmers before entering the pool, and regular laundering of swimming suits. "An ounce of prevention" is worth a pound of hypochlorite under any circumstances.

The HOUSEHOLD COMES *to the* LABORATORY

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The engineering skill which has been applied to the design of labor-saving devices for the home has made a number of these articles equal or superior to similar articles that are regarded as standard laboratory equipment. The methods of mass production used in their manufacture have brought the cost of numerous other items so low that they can be advantageously substituted for common equipment that is only a little better for laboratory use.

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THE contributions of the scientific laboratory to the comfort and convenience of the modern home have been so numerous and so well publicized that stories of new innovations are likely to seem trite and uninteresting. The laboratory's heritage from the home and workshop has been left unsung, and suggestions that methods or equipment intended for the kitchen might be used in scientific work are likely to be met with tolerant smiles. To be sure, the laboratory equipment of the great Berzelius has been likened to the pots and pans of a pioneer kitchen and several famous chemists of the last century won local notoriety in their younger days because of startling experiments performed in their homes. Even today every chemical laboratory contains a number of household utensils. The most familiar of these is perhaps the stone jar in which students are supposed to deposit burnt matches and other by-products of their quest for knowledge. If, because of this humble service, one is inclined to belittle the importance of domestic equipment, let him consider the uproar that is sure to ensue in any organic laboratory when some miscreant misplaces the ice-pick. This same ice-pick may properly hang beside an icebox that once saw service in a kitchen. Or if the institution is more prosperous, low temperature may be maintained by a modern electric refrigerator also intended for preserving a family supply of butter and ginger ale. Where the demand for pulverized ice is insufficient to warrant the purchase of a standard crusher, one of the household size may prove useful. There are laboratories in which even the cedar pail or hardwood chopping bowl with the seven-point pickstyle ice chipper would not be regarded as makeshifts, but as actual improvements.

As might be expected, a number of simple articles are available for use in the elementary courses. Every beginning student learns that iron will burn in oxygen by igniting a piece of picture wire or a small wad of steel wool. He might well test the activity of metallic lead by using lead wool intended for calking sewer pipe. He cuts glass with a taper file, but a wheel glass cutter costs no more, does better work, and lasts longer. The candles needed for the experiment on types of flames may be bought at the dime stores for less than the prices usually quoted by the scientific supply houses. Books of labels intended for household use are also cheaper than the boxed labels to which most chemists are accustomed. The instructor usually takes wood splints for granted, but the lab boy does not always find straight-grained wood suitable for making them. A fourth of a bundle of cedar shingles will solve this problem nicely. Cedar wood maintains a glowing spark better than pine, and so is distinctly superior for the oxygen test. Many teachers like a test-tube mounted on a glass foot for demonstration purposes. Miniature tall-form wine goblets having a capacity of about fifty cubic centimeters can be bought for about three cents each. Their appearance on a lecture table is surely more attractive than that of common test-tubes in a wooden rack. Half-pint milk bottles are both cheaper and better for the collection of gases than the common one-fourth-liter bottle generally used for this purpose. The extra-wide mouth of the milk bottle facilitates cleaning, lessens the chance of upset, and eliminates danger from explosion of hydrogen-air

mixtures. The shape and heavy weight minimize breakage. Standard cardboard caps are cheap enough for general laboratory use and permit the preservation of gas samples for some time. The same milk bottles and caps are also suitable for temporary storage of solid chemicals or samples. Many laboratories regularly use Mason jars for sample storage. Cold-cream jars, which can be obtained in sizes from two to sixteen ounces, are ideal for the storage of smaller samples. One-quart beverage bottles which can be bought at junk prices will often serve as well as common narrow-mouthed bottles of one-liter capacity. The use of dirty apparatus by students is one of the chief worries of every teacher of freshman chemistry. The students, however, are only partly to blame because ordinary soap in cold water is by no means a satisfactory cleanser for glassware that is coated with sulfide precipitates. Neither do acids and alkalies work well, and chromic acid cleaning solution in the hands of beginners is effective for nothing save the perforation of shirts and silk hose. A can of scouring powder of the type sold by the meat packers is both effective and foolproof.

Every student is supplied with some sort of spatula. The horn spatula is a standard article, but it is about as nearly worthless as a piece of equipment can be. Crystals and powders roll off its rounded blade so that transfer from bottle to test-tube is almost impossible. Measuring spoons made of synthetic resin and sold under the name of Safetyware can be bought in sets of four for ten cents. Their resistance to chemical action is about the same as that of horn, and they can really be used for measuring or transferring solids. The two larger spoons of each set may have to be thrown away, but the cost of each one used is still less than that of the horn spatula. The combination spoon and spatula of porcelain is superior to either of these, but, like them, it is too short to reach the bottom of a reagent bottle. Stainless steel spatulas are preferred for quantitative analysis, but their cost has made them impractical for use in general chemistry. However, table knives with stainless steel blades and Bakelite handles can be bought for less than twenty cents each. Similar knives with handles of a cheaper composition cost only ten cents. For flexibility and general convenience, these blades are almost equal to more expensive standard spatulas. Where a smaller and more flexible blade is needed as in weighing, a stainless steel grapefruit knife of the smooth-edge style is unsurpassed, and the curved blade is a real convenience. Iced-tea spoons of chromium-plated-nickel silver are also excellent for handling solid chemicals, particularly in the organic laboratory. Tablespoons of stainless steel are superior to any spatula for handling larger quantities of material in the preparation room.

The hemispherical iron dishes universally used for oil baths corrode rapidly. Aluminum mixing bowls of almost exactly the same shape and sizes can be bought from the large mail-order houses at prices very close to those usually paid for the iron dishes. The common copper water bath, too, is expensive, and it is not markedly superior to a cheaper aluminum pudding pan. Of course, the latter lacks the lid of concentric copper rings, but holes of the proper sizes can easily be cut in aluminum covers. Such one-piece lids have the advantage that loss of one does not ruin an entire set. The pudding pan's lack of the tubular overflow and tiny handles is no real defect. Aluminum dippers in pint or quart sizes can be used for the same purpose. The handles can be cut off, or holes can be drilled through them so they will slip over the rod of a support stand. For a deeper bath that will permit complete immersion of the bulb of a small distilling flask, an aluminum cocktail shaker is ideal. The tapered shape allows suspension in an ordinary ring and eliminates the possibility of overturning. For use with larger flasks, straight-sided aluminum pitchers or two-quart cream cans will be found satisfactory. Glass mortars are commonly preferred to the porcelain variety for grinding organic compounds. Small tumblers of heavy glass with hemispherical bottoms will serve nicely for grinding small samples. Small glass mixing bowls are available in exactly the same shape and sizes as the larger mortars and will be found economical as replacements.

The need for hot water in laboratory operations is so universal that the automatic gas-burning water heater might well find a place in institutions that take pride in the highest quality equipment. We still heat water in the one-liter wash bottle or the two-liter beaker and waste both gas and time because of the poor heat conductivity of the glass. A small teakettle might prove useful in almost any laboratory not provided with a more elaborate hot water system. One who hesitates to use water boiled in a metal vessel need only recall that most distilled water is prepared and stored in tin-lined copper. The possibility of wasting gas because the water is not visible can be avoided by getting a kettle of the whistling variety. This ultra-feminine touch is of real practical importance because a kettle of this type has only one opening. By replacing the whistle cap with a two-hole stopper carrying the usual outlet and safety tubes, one obtains a first-class steam generator for use in steam distillations. It is certainly superior to the balloon flask generator, and it is cheaper than a copper can made up on special order. The stockroom man must frequently heat considerable quantities of water for making solutions or for cleaning apparatus. The usual type of laboratory burner is not well suited for such work. A gas hot plate with a large range-type burner can be bought from the mail-order houses for a little less than the usual cost of a Meker-type burner. In addition to faster heating, the hot plate is more convenient for heavy work because there is less danger of upsetting the boiler. The spiral metal gas tubing recommended for use with these hot plates can be bought at a price so near that of common rubber tubing that it is worth considering for use with all burners. Another useful article for the storeroom is a corkscrew. The time and temper wasted in trying to remove a flat cork with a knife or file would

pay for half a dozen of these even if the cork were not so badly damaged that transfer to another bottle is necessary. When such transfers must be made, an enameled fruit-jar funnel will be found convenient.

Solid organic preparations are almost always dried on unglazed porcelain plates which oddly enough cost as much as or more than the cheaper grades of finished semiporcelain. While the porous structure certainly hastens drying, this advantage is often lost when several days intervene between laboratory periods. In such cases, the glazed article might well be used. Its economy is increased by the ease with which it can be cleaned and used again. For other preparations, paper plates are entirely satisfactory. The need for a low-pressure autoclave can be supplied with a steam pressure-cooker. One of these can also be converted into a small steam boiler by replacing the petcock with a standard needle valve. The fragile glass funnel usually placed beneath the receiver-condenser in vacuum distillations can be profitably replaced with an aluminum funnel. Or for larger-sized flasks, the reflector from an auto headlight can be used. The rubber policeman used by the analyst is limited in its usefulness by its small size. A plate scraper will be found excellent for removing crystals from large evaporating dishes. The all-rubber variety can be trimmed to a width of about an inch for more general work. If students persist in blunting the cork borers by driving them clear through the corks and into the table top, a heavy rubber pad known as a kneeling pad can be furnished for a backstop to save the cutters. For supporting round-bottom flasks in sizes below one liter, the usual cork rings are no better than all-rubber caster cups which can be bought for thirty cents per dozen. Crystallizing dishes are something of a luxury in many laboratories, but cereal dishes of translucent glass can be found in sizes that will meet nearly every requirement. Where greater resistance to heat is essential, pyrex custard cups can be pressed into service. If the sloping sides of these constitute a real objection to their use, the so-called refrigerator dishes with straight sides may prove more satisfactory.

Motor-driven stirrers are certainly to be placed in the class of necessities, but many laboratories are inadequately equipped because of the cost. For light work, such as stirring a melting-point bath, a windshield wiper motor is almost perfect. The modern household food mixer is surely rugged and powerful enough for nearly all types of work, but its usefulness is limited by its style of mounting. It is, however, a simple matter to remove the motor from its stand and attach it to a rod that can be held in an ordinary support clamp and to replace the metal blades with a chuck that will hold a glass rod. For heavy stirring, one of the cheaper electric bench drills will be found satisfactory. It has the disadvantage of rather heavy weight, and it needs to be bolted solidly to the table top. The resulting lack of portability can be largely overcome by mounting the drill on a small table fitted with casters so it can be moved to any part of the laboratory. Besides its possible use as a stirrer, such a tool may be of considerable value to the technician who wishes or needs to make equipment of wood or metal. An excellent shaking machine can be made from an old foot-power sewing machine. The sewing head is removed and a quarter-horsepower electric motor is mounted in its place and belted to the large drive wheel. The treadle forms the bed of the shaker and can be fitted with any desired type of cradle or clamping device. Strain on the motor and belt can be reduced by attaching four moderately strong springs between the corners of the treadle and the machine top. These should be strong enough to pull the shaker back to a horizontal position after it has been tipped to one side with a full load.

Those who have used the modern so-called solar evaporator which heats only the surface of a liquid agree that it is well worth its cost, but the chemist who cannot afford one can obtain almost the same results with an electric glow heater that costs three dollars and a half. One with a chromium-plated reflector and renewable screw-type heating element should be chosen. It works particularly well if a small fan is used to circulate air over the evaporating dishes. Electric hair driers have also been used to supply a stream of warm air for evaporation work. The modern table stove with two three-heat units, stainless steel burner covers, and chromium-plated frame is a worthy competitor for the standard laboratory hot plate with cast-iron top and fast-rusting frame. The former costs about seven dollars, but in comparing prices one should remember that it has two heating units. Electric ovens are generally found in even the poorest laboratories, but most of them are incapable of reaching a temperature higher than 180°. For the next higher temperature range of about two hundred degrees, there is no inexpensive standard appliance in common use. A little ovenette designed for baking on top of the stove will be found satisfactory if a hole is drilled in the top to accommodate a thermometer. One of aluminum should be chosen because of its resistance to corrosion. A Dutch oven has a larger capacity. For still heavier service, one can buy a little electric rangette with two open burners mounted on top of a small oven for twenty dollars. A gas rangette with two burners and a fair oven can be had for half this price. For occasional use in drying small samples at 100°, a common double boiler is both efficient and very cheap.

An exact duplicate of one of the standard forms of funnel heater can be made in twenty minutes from a coil of copper tubing which costs thirty-five cents. A similar heater for a Buchner funnel is only a little harder to make. This heater should be strengthened by a framework of metal strips which will hold the coils in position. The end of the coil should be cut off close to the funnel and a union must be provided for connecting to the heater. An excellent superheater for steam can be made from the same sort of copper tubing. A piece of one-inch pipe about a foot long is wrapped with sheet iron and the copper tubing is wound around this. A strip of sheet iron of the same

width as the outside diameter of the pipe is twisted so that it makes a full turn in about four inches of length, and it is slipped into the sheet-iron tube when the pipe is removed. The copper tube is covered with furnace cement and wrapped in asbestos paper. The heater is so mounted that it serves as a chimney for a Meker burner. The twisted metal strip effectively directs the heat against the side of the heater and the iron lining protects the copper from oxidation. Connection to glass tubing is effected by means of a sleeve-type union. Glass of about the same diameter as the copper is slipped through the union nut and the space intended for the little copper sleeve is packed with plumber's candlewicking or soft cotton twine.

Compressed air is another commodity that is not universally available in small educational laboratories. One of the cheapest means of providing it is a small diaphragm-type compressor designed for paint spraying. This costs a little over three dollars, and a used motor suitable for operating it can probably be found for about the same price. A larger compressor of the same type but with a capacity of about two cubic feet per minute costs only ten dollars. If still larger capacity or higher pressure is desired, or if service is to be carried over an entire building, a compressor unit intended for filling station or garage use is worth considering. Its ruggedness cannot be questioned, and its price is markedly less than that of some outfits that have been offered for laboratory use. Where pressures of more than fifteen to twenty pounds must be handled, the all-rubber tubing universally used for chemical work is not entirely satisfactory. Three-ply fabric-reinforced hose suitable for pressure work can be bought economically as automobile pump tubing in $^3/_{16}$- and $^1/_4$-inch sizes or as sprayer hose in larger diameters. Such tubing is also satisfactory for semipermanent gas and vacuum connections.

Apparatus for analytical chemistry is so specialized that only a few satisfactory substitutions can be suggested. Small artists' brushes cost only a little more than the little single-quill camel's-hair brushes used for dusting weights. The five-inch wood handles of the former make them more convenient. Larger sizes offer marked economies in comparison with corresponding quill-handled brushes. Heavy braided cotton fishline makes a perfect replacement for wornout cords on the doors of balance cases. Since the filter flasks now obtainable have uniformly smooth vial mouths, even the best of the patented adapters for Gooch crucibles are but little superior to the very simplest made by cutting a hole in a rubber disc taken from a discarded inner tube. Chemists who need to make occasional physical measurements have long been accustomed to using large stone jars for constant-temperature water baths. One of these can be insulated sufficiently to make it equal to a more expensive tank by placing the water jar in a larger one and filling the intervening space with rock wool commonly sold for attic insulation. A waterproof cover for the annular space can be cut from a sheet of tempered Masonite and sealed to the jars with plastic wood and lacquer. The "Hot-do-nut" type of immersion heater will be found satisfactory for such a water bath if continuous service is not required. Such a heater costs less than a dollar.

It is to be emphasized that a number of the things which have been described are not to be regarded as inferior substitutes but as articles of quality which are worthy of comparison with the best standard equipment intended for similar purposes. Several other items have no counterparts among the offerings of most of the scientific supply houses but are nevertheless to be found in many laboratories. The articles of a third group have attained sufficient importance to be given places in the supply catalogs. These have been mentioned partly because of their origin and partly because a prospective purchaser may find the models or prices best suited to his needs or budget only by examining a number of sources of supply. Low cost is still the principal merit of many of the articles, but this is likely to remain a factor of paramount importance in many institutions for some years to come. Fortunately these same institutions are the ones most likely to find true economy in the purchase of inexpensive apparatus. For a small laboratory to purchase a piece of equipment designed for continuous heavy duty service and then use it only occasionally is probably a waste of money, whereas purchase of a cheaper article for another laboratory may be gross extravagance. The articles suggested will be found satisfactory under some conditions, but the limits of these conditions must not be overlooked.

There are also some objections to using this type of equipment which are not connected with shortcomings of the utensils. A little shopping may be necessary to find some, and the time so spent may amount to more than the money saved. The alterations necessary to make some usable may require a degree of mechanical skill which not every chemist has developed. A few things have been mentioned chiefly because they can be obtained locally on short notice, and this advantage diminishes as the laboratory's increasing size or prosperity permits a wider selection of equipment or the maintenance of a larger reserve stock. The quantity discounts obtainable on large orders reduce the price differences and the possible savings and so further restrict the use of this type of equipment to the smaller institutions.

Finally, the household equipment can seldom be included in lists sent out for bids, and this may lead to the greatest obstacle of all—that of getting the necessary requisitions approved by the purchasing department. A startled business manager is unlikely to allow an order for things that he believes could be used only by the department of home economics. Or a purchasing agent who believes that teachers have no business acumen may feel that lack of catalog numbers gives him a good opportunity to indulge a yen for making substitutions, and a chemist who orders a table stove may be surprised by the delivery of a waffle iron.

APPARATUS *and* EXPERIMENTS *for* INSTRUCTION *in* POTENTIOMETRIC MEASUREMENTS

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A potentiometer, hydrogen generator, and calomel electrode which are simple, relatively inexpensive, and especially suitable for student use are described. A discussion of the available experiments indicates the desirability of assigning further work after the completion of the usual experiments on neutralization and determination of pH. Precipitation reactions are often readily followed and interpreted by potentiometric measurements and are particularly fruitful for teaching purposes. Not only is the form of the curve of interest, but in many cases several types of semiquantitative calculations which relate numerous aspects of the subject can be made. Two convenient experiments which are capable of a wealth of interpretation are discussed in detail.

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THE use of potentiometric measurements of such cells as that employing hydrogen and calomel electrodes is well recognized as a versatile teaching device. These measurements supply a forceful method of demonstrating and relating many terms which are often confusing—such as pH, acidity, activity, neutralization, equivalence—and provide an excellent means of following and interpreting the course of many types of reactions. It is the purpose of this paper to describe an assemblage of apparatus and choice of experiments designed to make these measurements of even greater pedagogical value than as commonly presented.

APPARATUS

It is true that the student should not be required to spend much time in constructing a set-up; neither, it would seem, should he be given an apparatus which is permanently enclosed in a container revealing only a few dials and binding posts. The former not only wastes time and patience but often leaves the student with the impression that the method is impractical.[1] The latter, besides often involving apparatus which is prohibitively priced for use with large numbers of students, hides many of the important principles involved in the measurement. The apparatus* described hereafter obviates these difficulties, being simple and inexpensive as well as complete and efficient. Only the calomel electrode and the hydrogen electrode with its hydrogen source are detached, the remainder being a complete potentiometer having only two connections to be made to the electrodes by means of binding posts.

This potentiometer, shown in Figure 1, uses the arrangement suggested by Hildebrand.[2] The instruments are mounted on a board $\frac{3}{4}'' \times 11\frac{1}{2}'' \times 18''$, fitted with small rubber feet. The connections throughout are of bus bar with soldering lugs used as terminals. The switch in the galvanometer† circuit is of an ordinary doorbell type and is so placed that the operator can conveniently press the button and the voltmeter switch simultaneously with two fingers of one hand. The battery is wired to the board so that it can be replaced readily, and use of the knife-switch prevents

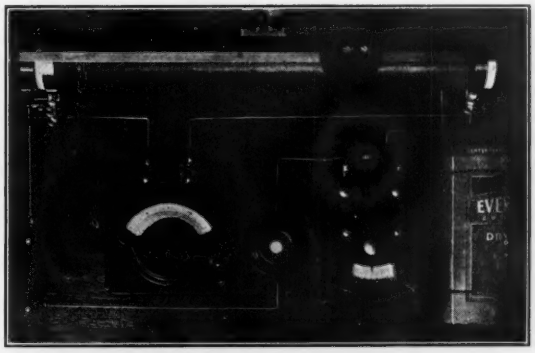


FIGURE 1

[1] PARKER, H. C., "Electrical measuring instruments for use in teaching electrochemistry," J. CHEM. EDUC., 7, 69–80 (Jan., 1930).

* The writers are indebted to Mr. Robert T. Gore for aid in the design of apparatus.

[2] HILDEBRAND, J. H., "Some applications of the hydrogen electrode in analysis, research and teaching," *J. Am. Chem. Soc.*, 35, 847–71 (July, 1913).

† Apparatus of a type suitable for use in an assemblage such as that described above can be obtained from numerous sources. The galvanometer shown in Figure 1 is a Leeds & Northrup instrument, and the voltmeter is one made by the Weston Electric Instrument Corporation. The instrument shown in the picture has a range up to two volts with divisions of 50 millivolts, making possible estimation of the readings to five millivolts. More recent voltmeters made by this same concern are equipped with mirrors behind the scale to obviate parallax in reading, and have divisions of 20 millivolts over a range of 1.2 volts, permitting estimation to two millivolts. An instrument of this latter type was used in the experiments for which data are given.

the necessity of replacement over a long period. The voltmeter is held to the board by L-screws, the upper arms of which are snugly covered with "spaghetti" tubing. The variable rheostat is a 120-ohm, 2-ampere instrument. The two binding posts placed at the left of the board can be marked or left for the student to identify by consideration of the circuit.

This potentiometer is rugged in construction, has few parts to manipulate, shows every part of the working circuit, and is relatively inexpensive. A further and unexpected advantage of the present set-up is that students, in general, seem to treat it with greater care than when the delicate parts are in an enclosed unit. While it is described here for use with the hydrogen-calomel cell, it has also proved satisfactory when used with many other cells. A closet of inside dimensions $12^1/_2'' \times 18'' \times 42''$, fitted with guide pieces onto which the boards can be slid one above another, will hold seven of these for storage in an easily accessible condition.

The hydrogen electrode used is of the Hildebrand type[2] and is fed by an electrolytic generator of the form pictured in Figure 2. This consists of a cell of sodium hydroxide solution electrolyzed between nickel and platinum electrodes. The platinum anode, situated in the tall center tube whose liquid level serves both to indicate the pressure and maintain a more constant flow of gas, liberates the oxygen through that tube. A steady head of hydrogen, regulated by the stopcock and lamp bank, is led through the wash bottle to the electrode.

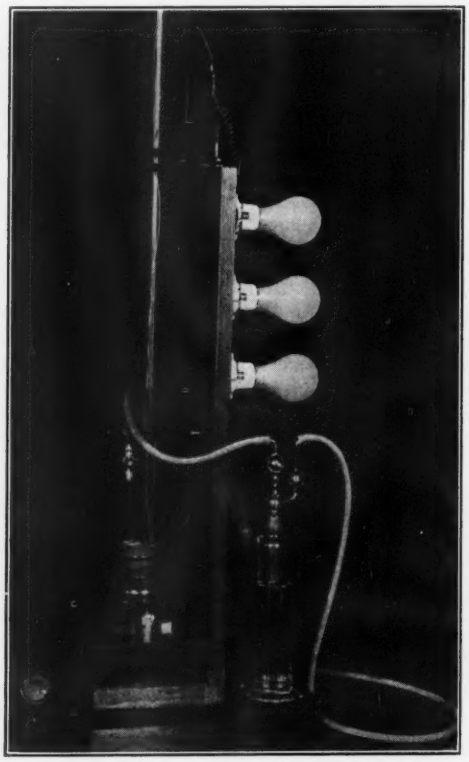


FIGURE 2

The calomel electrode vessel, drawn to scale in Figure 3, is of very simple construction. Its overall height is 8″ and the central tube is $^7/_8''$ in outside diameter, allowing the cell to be held by a buret clamp. The side arm has small holes for contact with the solutions and can conveniently be filled at its lower end with a gel of 6% agar in normal potassium chloride. A sleeve cut from rubber tubing is used to cover the holes of this arm while the electrode is not in use; this prevents displacement of the gel or loss of the electrode solution. A solid stopper is used to cap the electrode in order to prevent evaporation and possible siphoning while in use. Diffusion through the gel seems to be very small as seen in titration of colored solutions, and thus the electrode is sufficiently permanent for general student use. In any case, it is a simple matter to change the solution from time to time without disturbing the gel. Using normal potassium chloride in tests of these electrodes against buffers and other solutions of known hydrogen-ion activity, they were found to be quite reproducible and of value not far removed from that of the true normal calomel electrode.

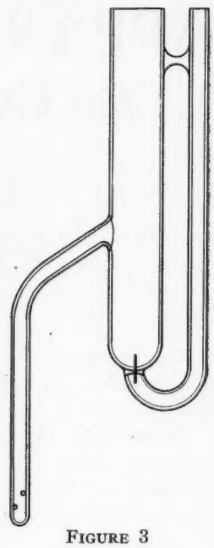


FIGURE 3

EXPERIMENTS

For the cell discussed in this paper, the selection of experiments found in laboratory manuals is very limited. The usual experiments, dealing generally with titration of common strong and weak acids and bases, or with determination of the pH of buffers and colored solutions, are of utmost importance. In attempting to gain the greatest pedagogical value from these, it seems appropriate in physical chemistry to emphasize the interpretation of the form of the curves obtained in a number of different cases rather than the analytical aspects of the method. However, it has been found that if small amounts of both phenolphthalein and methyl orange are introduced in the titration of strong and weak acids and their mixtures, the student receives a much clearer insight into the use of indicators in general, a striking demonstration of the errors which may occur in the use of the wrong indicator and a renewed understanding of the difference between titration to the equivalent point and to the neutral point. Such experiments, however, may profitably be followed by others which will require the application and extension of the principles learned in the more simple experiments.

In selecting these less common experiments it is an excellent practice to assign a definite titration to each student, merely directing him to follow the course of a

given reaction. This requires his choosing the reagents, the order of addition, the quantities, and, in general, an application of his training and ingenuity to a situation which he might well meet in future work. The student should be urged to search the literature himself in seeking interpretation of his results. The instructor might be guided in his choice of experiments by such source books as that of Britton.[3]

This practice has been found successful with many students of superior ability, but for less superior students, especially if the time is limited, it is better supplanted by assignment of experiments for which directions are given in definite literature references. These may be obtained from current journals or from certain more recent laboratory manuals.

A digest of the literature and trials in the laboratory indicate that experiments following the course of a precipitation reaction are especially useful for these assignments. To choose two examples, we might cite the precipitation of magnesium hydroxide, a reaction which has long been used successfully as a student experiment,[3,4] and the precipitation and dissolution of aluminum hydroxide. This latter is of unusual interest and shows well the rôle of peptization and complex formation in such reactions.[2,3,5] Many other examples of this type are found in the text by Britton and will serve especially well in following the first practice described above.

The writers have used two experiments particularly which may illustrate, in their simplicity and interpretation, the type generally applicable to the requirements of a student laboratory.

TITRATION OF SODIUM BENZOATE WITH HYDROCHLORIC ACID

In the first of these experiments, the reaction of sodium benzoate with hydrochloric acid, the change of pH with addition of acid is shown in Figure 4. This titration can be used to determine the purity of the sodium benzoate, the solubility of benzoic acid, and the dissociation constant of benzoic acid, besides showing the effect of hydrolysis on such salts as sodium benzoate. The results of the titration of 2.160 grams of dried U.S.P. sodium benzoate in 350 cc. of water with 1.4865 normal hydrochloric acid appear in Table 1 as typical. Here the voltmeter readings were changed to corrected pH by a factor established in testing the cell against solutions of known hydrogen-ion activity. There are also listed the value of the pH calculated from the dissociation constant of benzoic acid (6.6×10^{-5}) and the amount of hydrochloric acid added to the solution (see below). The pH of the original solution of sodium benzoate before addition of hydrochloric acid was calculated from the ion product constant of water, the concentration of the salt, and the dissociation constant of benzoic acid in the usual manner.

TABLE 1

THE TITRATION OF SODIUM BENZOATE* WITH HYDROCHLORIC ACID AT 20°C.

Cc. of Acid (1.4865 *N*)	E.M.F. (*volt*)	pH (*corrected*)	pH (*calculated*)
0.0	0.662	6.84	8.41
0.1	0.622	6.16	6.18
0.2	0.612	5.98	5.87
0.3	0.600	5.78	5.69
0.7	0.575	5.35	5.30
1.2	0.555	5.00	5.05
2.02	0.538	4.71	4.78
3.00	0.526	4.50	4.55
4.0	0.508	4.19	4.36
5.0	0.490	3.88	4.18
†6.0	0.482	3.74	4.00
7.0	0.474	3.60	3.81
8.0	0.468	3.50	3.58
8.80	0.450	3.19	3.25
9.0	0.445	3.10	3.23
9.20	0.440	3.02	3.12
9.40	0.438	2.98	2.99
9.65	0.425	2.76	2.74
10.00	0.410	2.50	
10.20	0.400	2.33	
10.40	0.390	2.16	
10.60	0.385	2.07	
11.00	0.375	1.90	
11.50	0.370	1.81	
12.00	0.368	1.78	
12.50	0.368	1.78	
14.00	0.364	1.77	

* 2.160 g. of dried U.S.P. sodium benzoate was used in 350 cc. of water.
† Point of first separation of benzoic acid.

The smooth curve in Figure 4 is that drawn for the theoretical values up to the endpoint, after which it is drawn through the observed data. The values of Table 1 show that this is justified except in the case of the first point. The circle denotes the observed pH

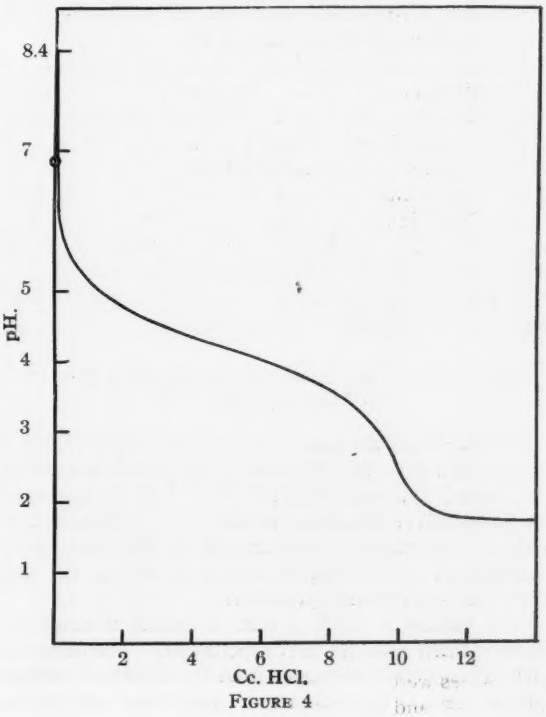


FIGURE 4

[3] BRITTON, "Hydrogen ions," 2nd ed., Chapman and Hall, Ltd., London, **1932.**

[4] HILDEBRAND AND HARNED, "The rapid determination of magnesia in limestone by means of the hydrogen electrode," *8th Intern. Congr. Appl. Chem.*, **1,** 217 (1912); KOLTHOFF AND FURMAN, "Potentiometric titrations," 2nd ed., John Wiley & Sons, Inc., New York City, **1931,** p. 211.

[5] CURTMAN, "Qualitative chemical analysis," The Macmillan Company, New York City, **1934,** pp. 196–8.

before any acid was added. It is noted that the observed value is lower than the calculated pH. This observation has been consistent, the solutions always being slightly acidic, probably due to a small amount of free benzoic acid. It is easily seen from the steepness of the curve at the start that a very slight amount of acid will cause an error of the type observed. The value obtained for the addition of only 0.1 cc. of HCl is practically the calculated one, again showing that the discrepancy of the original value is understandable. Thus the first part of the curve shows the enormous effect of hydrolysis and how impurities enter in this effect.

The inflection of the curve at equivalence is used to calculate the purity of the sodium benzoate from the normality and the amount of the acid. In this experiment 10 cc. of the 1.4865 *N* HCl was equivalent to 2.160 grams of salt, showing the salt to be 99.1% pure in agreement with U.S.P. standards.

The dissociation constant of the acid can be calculated from the hydrogen-ion concentration (activity) at any point on the curve between the start and the equivalent point by the following reasoning. The benzoate-ion concentration will be $(e - x)$ where e is the amount of acid required for equivalence and x is the amount to reach the point whose hydrogen-ion concentration is measured. The benzoic-acid concentration will be x. Therefore, the value of the dissociation constant, K, will be given by the equation:

$$K = C_{H^+}(e - x)/x$$

Comparison of the values in the table shows how well this is obeyed, the theoretical pH values having been calculated from the true value of K.

Finally, this experiment may be used to determine the solubility of benzoic acid. The amount of acid which causes the first permanent separation of shimmering plates of benzoic acid is easily detected. The volume of the solution and the amount and normality of the acid allow a calculation of the saturation concentration of benzoic acid. In this experiment 6 cc. of HCl was required, corresponding to a solubility of 0.0255 mole per liter in the solution containing sodium chloride and sodium benzoate as compared with 0.0278 moles per liter in pure water at 25°C.

TITRATION OF AMMONIUM CHLORIDE WITH SODIUM HYDROXIDE

The results of the second experiment, the titration of ammonium chloride with sodium hydroxide, are shown in Figure 5 and are listed in Table 2. This experiment shows the effect of hydrolysis of such salts as ammonium chloride and allows the calculation of the dissociation constant of ammonium hydroxide as well as the normality of the sodium hydroxide.

The values in Table 2 were obtained in much the same manner as in the first experiment. The corrected pH values were determined from the observed voltages of the cell and the calculated values were obtained as follows. The pH before any base was added was calculated from the ion-product constant of water, the concentration of the salt, and the dissociation constant of the base. The other calculated values were obtained from the amount of base added, the amount required for equivalence, and the dissociation constant of ammonium hydroxide (1.8×10^{-5}). Figure 5 was drawn from these calculated values up to the equivalent point, after which the curve was passed through the correct observed values. That this was allowable may be seen from the table.

TABLE 2

THE TITRATION OF AMMONIUM CHLORIDE* WITH SODIUM HYDROXIDE AT 20°C.

Cc. of base (ca. 0.4 *N*)	E.M.F. (*volt*)	pH (*corrected*)	pH (*calculated*)
0.0	0.485	3.79	5.32
0.8	0.684	7.22	7.83
1.2	0.726	7.95	8.02
1.6	0.740	8.19	8.15
2.0	0.750	8.36	8.26
3.0	0.758	8.50	8.45
5.0	0.770	8.71	8.72
7.0	0.786	8.98	8.92
9.0	0.795	9.14	9.10
11.0	0.801	9.24	9.26
14.0	0.815	9.48	9.50
17.0	0.830	9.74	9.79
19.0	0.842	9.95	10.06
20.0	0.858	10.22	10.26
21.0	0.870	10.43	10.58
22.0	0.896	10.88	
23.0	0.917	11.24	
24.0	0.928	11.43	
25.0	0.944	11.71	
26.0	0.950	11.81	
28.0	0.956	11.91	
30.0	0.960	11.98	

* 0.4280 g. of C.P. ammonium chloride was used in 200 cc. of water.

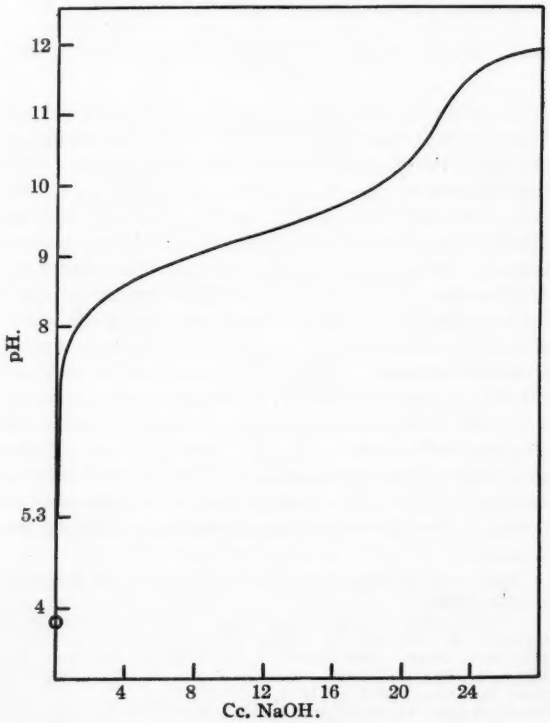


FIGURE 5

Again, the observed value of the pH was lower than that calculated for the solution of ammonium chloride in water before the addition of base, whereas on addition of base the values are in good agreement with the theoretical. The steepness of the curve shows that slight impurities could easily cause this error, and although quantitative calculation of the extent of hydrolysis is impossible, the qualitative effect is well indicated.

The inflection point at equivalence can be used in this case to estimate the normality of the base since ammonium chloride can readily be obtained in a very pure condition.

The graph can be used to calculate the dissociation constant of ammonium hydroxide even if the strength of the base is not known. The hydroxyl-ion concentration at any point in the addition of sodium hydroxide before equivalence can be calculated from the ion-product constant of water and the observed hydrogen-ion concentration at that point. This, together with x, the amount of sodium hydroxide required to reach that point, and the amount e, required for equivalence, will give K, the dissociation constant, by the equation:

$$K = C_{OH^-}(e - x)/x$$

In the table, however, it has seemed best to give the data in such a way that the pH values at each point could be compared rather than in a manner in which the constancy of K would be indicated.

A SCHOOL IMITATION *of* DUMAS'S EXPERIMENT

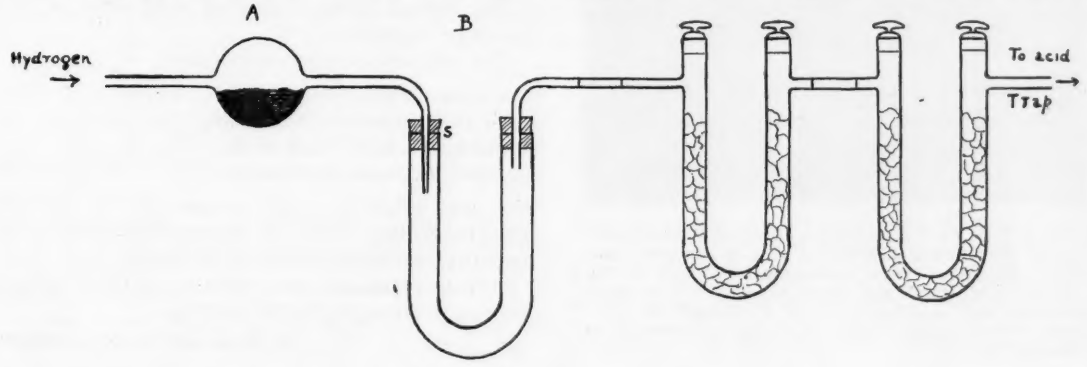
WILLIAM T. BROW

George Heriot's School, Edinburgh, Scotland

THE following imitation of J. B. A. Dumas's famous experiment where the combining weights of hydrogen and oxygen were determined has been used with success in the laboratory classroom for the determination of the equivalent of oxygen. As a class demonstration it gives an excellent result if the manipulation is carefully carried out. The whole experiment may be carried out in approximately eighty minutes, a great advantage since it can be completed during the time allotted in the classroom at one visit. It demonstrates the careful manipulation of delicate apparatus and serves as a good lesson in quantitative measurement.

The apparatus used was much less elaborate than Dumas's, and the U-tubes employed were of ordinary size.

Hydrogen gas was made in a Woulff bottle containing commercial zinc and a dilute solution of pure sulfuric acid which had been previously boiled for a few minutes to expel air and gases. There was the usual mercury seal to allow the hydrogen to escape in the event of too great a pressure. The gas was passed through a solution of silver nitrate, and then through potassium permanganate solution for purification, both solutions being contained in Drechsel bottles. The gas was then dried by passing it over anhydrous calcium chloride contained in three U-tubes. The hydrogen now passed through a bulbed tube (A) blown from a medium-walled piece of ordinary glass tubing, and then drawn out to a narrow end and bent at right angles as in sketch. The bulb was half filled with pure dry copper oxide wire and weighed without the rubber connection but with the small rubber stopper (S) at the narrow end. Most of the water formed in this bulbed tube by the combination of the hydrogen with the oxygen of the oxide was trapped in an empty U-tube which may be surrounded by a freezing mixture. This U-tube represents the bulbed tube used by Dumas for catching the bulk of the water. The empty U-tube was weighed, along with the next stoppered U-tube filled with anhy-



drous calcium chloride, the rubber connection between the two being left in position. A small rubber stopper was used to close the empty U-tube (*B*) to prevent evaporation of the water. A second stoppered U-tube filled with anhydrous calcium chloride was used as an absorber also, but this was weighed separately. Finally, the excess hydrogen was allowed to escape through a sulfuric acid trap which prevented moisture of the air entering the absorbers. Before weighing was begun all air was swept out of the apparatus, and the absorption tubes to be weighed were closed. The reducing temperature is low and, after sufficient water had been collected, the bulbed tube was allowed to cool down while the hydrogen gas was still being passed through.

The bulbed tube was weighed both before and after the reduction filled with air, while the absorbers were weighed filled with hydrogen both times. After the apparatus had cooled to room temperature, the bulbed tube was allowed to stand in the balance case and weighed last to give the hydrogen time to escape.

REPRESENTATIVE EXPERIMENTAL DATA

	g.
Weight of bulbed tube + copper oxide	27.6275
Weight of bulbed tube + residue	26.3943
Weight of oxygen	1.2332
Before reduction:	
Weight of 2 absorbers	38.4255
Weight of 3rd absorber	19.7732
Total	58.1987
After reduction:	
Weight of 2 absorbers	39.8135
Weight of 3rd absorber	19.7734
Total	59.5869
Weight of water formed	1.3882
Weight of hydrogen	0.1550

0.155 g. of hydrogen combines with 1.2332 g. of oxygen.

$\therefore$ 1 g. of hydrogen combines with $\frac{1.2332}{0.155} = 7.95$ g. of oxygen

or 16 g. of oxygen combines with 2.011 g. of hydrogen.

An average of nineteen experiments by Dumas gave 16 parts by weight of oxygen combine with 2.004 parts by weight of hydrogen.

Prof. J. R. Katz, of Amsterdam, Holland, George Fisher Baker Non-resident Lecturer at Cornell University last year. Prof. Katz is an international authority on the chemistry of starch and starch products. The above snapshot was taken by Prof. C. W. Foulk upon the occasion of Prof. Katz's visit to Ohio State University in March, 1935.

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF THE DIVISION OF CHEMICAL EDUCATION

The Executive Committee of the Division met in Pittsburgh on September 9th. Present: H. Hale (Chairman), N. W. Rakestraw, Virginia Bartow, R. A. Baker.

It was voted to publish an abstract, if possible, of the recent report of the Committee on Chemical Education of the Non-collegiate Type, and to make the complete report available in mimeographed form.

Dr. G. J. Esselen was re-elected to the Board of Publication.

N. W. RAKESTRAW, *Secretary*

MINUTES OF THE ANNUAL BUSINESS MEETING OF THE DIVISION OF CHEMICAL EDUCATION, A. C. S.

The annual business meeting took place in Pittsburgh on September 10th.

The following officers were elected:

Chairman: O. M. Smith
Vice-chairman: E. W. Phelan
Secretary: N. W. Rakestraw
Executive Committee Member-at-large: M. V. McGill

It was voted to appoint a committee to coöperate with the College Entrance Examination Board in formulating new requirements in chemistry.

A vote of thanks was extended to the Pittsburgh Section in arranging for the meeting.

N. W. RAKESTRAW, *Secretary*

DETECTION *of* BARIUM ION *in the* PRESENCE *of* PHOSPHATE ION

T. W. DAVIS AND NATHAN KORNBLUM

New York University, University Heights, New York City

A STANDARD method of removing phosphate ion before the analysis of Group III is to buffer an acid solution with ammonium acetate and precipitate a mixture of ferric, aluminum, and chromic phosphates, together with basic acetates of these three ions.[1]

It was noted that a beginning class at New York University seldom or never reported barium in Group IV in quantities of 8 to 20 mg. per 10 ml. sample of "unknown" when phosphate ion was thus removed. The percentage of correct reports of the presence of barium in one year was less than ten. The class in which the record was noted numbered forty-four students, mostly freshman chemical engineers and arts students majoring in chemistry.

Since barium phosphate is soluble under the conditions of removing ferric phosphate, it is evident that the barium is lost through adsorption. A procedure was introduced, therefore, providing for the isolation and detection of barium from the phosphate precipitate. This involves treatment with sodium peroxide to dissolve aluminum and chromic phosphates, and subsequent solution of the ferric phosphate and ferric basic acetate residue in 6 *N* hydrochloric acid. Ammonium sulfate (1 *N*) is added to this hydrochloric acid solution, and the mixture is heated to boiling. A white precipitate of barium sulfate indicates the presence of Ba^{++}, and this is confirmed through a flame test made in accord with the following procedure. The barium sulfate is filtered and washed thoroughly with hot water. A platinum wire is wrapped around the paper containing the precipitate, and after drying over a small flame, the paper is charred and burned off. A residue of barium sulfide remains. This is moistened with hydrochloric acid and introduced into the Bunsen flame. A green flame confirms the presence of barium.

One mg. of Ba^{++} per 10 ml. of solution can be positively detected in this way—an immediate precipitate being secured with ammonium sulfate—but it is difficult to obtain a good flame with this amount. With the old procedure, the smallest amount of barium which could be identified in the presence of phosphate was 20 mg. per 10-ml. sample, and this happened to be the maximum concentration appearing in our unknown solutions. As a result of the introduction of the new procedure, the percentage of correct reports of the presence of barium has increased from less than ten to seventy-five. It is interesting to note that barium was not erroneously reported in spite of the fact that considerable difficulty was anticipated with beginners handling the technic of ashing filters and using the residue for a flame test. A small amount of sodium is always picked up from the fingers in wrapping the platinum wire around the filter paper, but this does not ordinarily obscure the barium, nor lead to frequently imagined green flames.

Strontium is not missed in the presence of phosphate, with the usual procedure, unless the amount of phosphate ion is rather large (about 100 mg. per 10 ml.) or the amount of strontium small. Students had no difficulty finding 10 mg. of strontium, but consistently missed 5 mg. No new procedure, however, has been adopted to provide for the detection of these smaller amounts of strontium.

The number of correct reports of the presence of barium when phosphate is present is given in the table subjoined. The record is taken from a beginning class of forty-one students. We include in the table data on the detection of barium and strontium when phosphate is absent but when Group III is present. The figures cited indicate that the loss of Ba^{++} resulting from oxidation of Group III sulfides is in most cases unimportant.[2] Since the strontium test is not ordinarily regarded as entailing any special difficulties, a record of the reports for strontium appears also for comparison. The amounts of Ba^{++} and Sr^{++} in the solutions varied from 5 mg. to 20 mg., and the PO_4^{---} from 25 mg. to 100 mg. per 10 ml.

TABLE

Ba^{++} AND Sr^{++} DETECTION

	With Phosphate Present		With Phosphate Absent	
	Found	*Missed*	*Found*	*Missed*
Ba^{++}	21 reports	7 reports	9 reports	2 reports
Sr^{++}	18 reports	9 reports	9 reports	6 reports

CONCLUSION

With a given class, we might regard the reports for strontium as setting a standard with which to compare reports for the other ions, since the strontium test usually causes no great difficulty. The figures in the table show that the modified barium procedure leads to a higher percentage of correct reports than is found for strontium. And at all events, the modified procedure is far more satisfactory than the usual procedure for detecting barium in the presence of phosphate.

[1] MILLER, F. W., "A laboratory manual of qualitative analysis," D. Appleton-Century Co., New York City, 1930, p. 82.
REEDY, J. H., "Elementary qualitative analysis," 2nd ed., McGraw-Hill Book Co., New York City, 1932, pp. 63–4.
CURTMAN, L. J., "Qualitative chemical analysis," The Macmillan Co., New York City, 1931, pp. 440–2.
NOYES, A. A., "Qualitative chemical analysis," 9th ed., The Macmillan Co., New York City, 1928, p. 105.

[2] CURTMAN AND FRANKEL, *J. Am. Chem. Soc.*, 33, 724 (1911).

An AUTOMATIC GAS GENERATOR

IRVING FINE

Morris High School, Bronx, New York

ABOUT five years ago, in an elementary course in qualitative analysis, the question arose as how to best generate the required H_2S. Although a Kipp generator was tried for a time, its use soon had to be discontinued. The apparatus proved to be too great a temptation to some of the more mischievous students, with the result that it was frequently out of commission just when needed.

Recourse was then had to individual test-tube generators, but these also had to be discarded, due to the unavoidably large supply of gas that was evolved.

An extremely satisfactory solution to the problem was gradually worked out and is illustrated in Figures 1 and 1*a*. A piece of copper strip, $1\frac{1}{2}$ inches wide and about 4 inches long, was bent into the form of a triangle and placed on edge in a standard wide-mouthed bottle. A circular piece of copper gauze, of the same diameter as the inside of the bottle, and with a $\frac{1}{2}$-inch hole in the center, was placed on the supporting copper strip. The ferrous sulfide was put upon the gauze, and the bottle was stoppered with a two-hole stopper carrying a delivery tube and a glass funnel. (After much experience with the unavoidable breakage that commonly results when thistle tubes are used, Mr. Gustav L. Fletcher, Chairman of the Physical Science Department, James Monroe High School, Bronx, New York, had for some time past been using funnels instead. This practice certainly makes for greater economy and is to be strongly commended.)

A screw clamp, attached to the delivery tube line, effectively controls the evolution of gas. When the clamp is closed, the excess acid collects in the funnel and the reaction stops.

To charge the generator, the bottle is inclined and the ferrous sulfide is placed upon the gauze, care being taken that none drops below the gauze.

After stoppering the bottle and standing it upright, the clamp is opened and enough acid is added through the funnel to make contact with the ferrous sulfide. Minor adjustments of the clamp can then be made to regulate the flow of gas.

(If the funnels available are too short to reach to the bottom of the bottle, the stems should be lengthened by additional pieces of rubber or glass tubing.)

It is advisable to stand the bottle in a ring on a ring stand; this will eliminate accidental tipping. As an additional safeguard against spilling of the acid, the funnel may be covered with a watch glass.

This model can easily be adapted to the preparation of such gases as H_2, O_2 (oxone method), CO_2, HCl, SO_2 (Na_2SO_3 method), C_2H_2, Cl_2, CO, NO, and NO_2.

Upon Mr. Fletcher's suggestion, an attempt was made to have the wire gauze anchored firmly in the bottle by means of a series of hollow glass studs, arranged horizontally, and molded in the bottle during manufacture. A bottle of this design was made, but a perforated Coors porcelain filter disc, with a $\frac{1}{2}$-inch hole in the center, was substituted for the copper gauze.

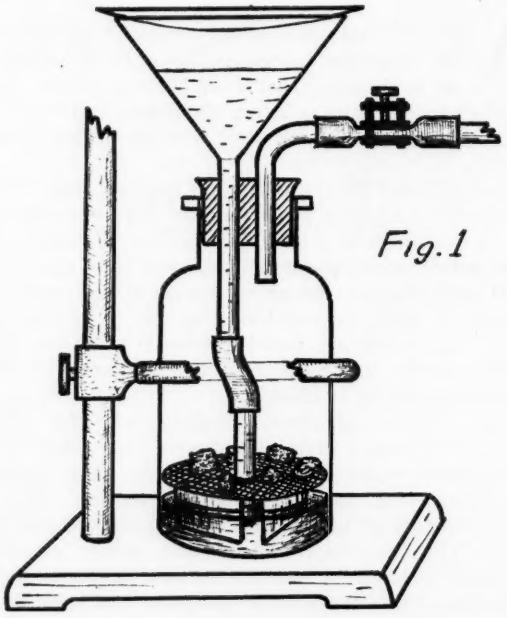


Fig. 1

Standardizing on such a single generator, capable of being distributed for individual pupil use for making any of the gases commonly required, obviously has many advantages. There is no longer any need for stocking such a large variety of flasks and bottles of different types and sizes; automatic control makes for greater economy in the use of reagents; the need for hoods is minimized; the work of the pupil, the teacher, and the laboratory assistant is greatly simplified.

For quantity production of gases, a larger generator can be used in which the funnel is replaced by a tube leading to a supplementary storage bottle (Figure 5).

A description of some of the other preliminary models developed, all of which have been tried out in the classroom, might be of interest.

Figure 3 illustrates a design in which pebbles were used. Although this model was used to prepare each of the gases ordinarily required in a high-school course, it had one drawback. At times, small particles of the solid reagent used would drop down into the spaces between the pebbles, interfering greatly with the automatic control.

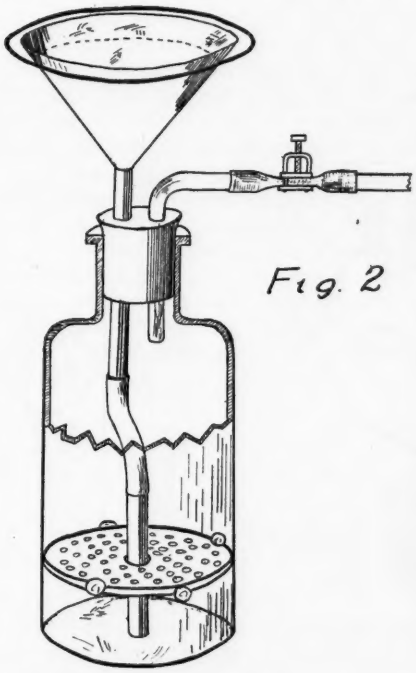


Fig. 2

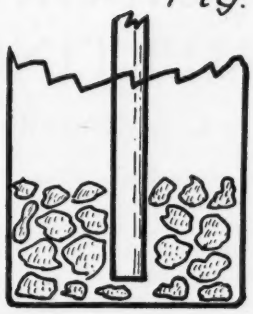


Fig. 3

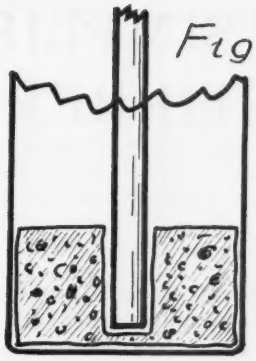


Fig. 4

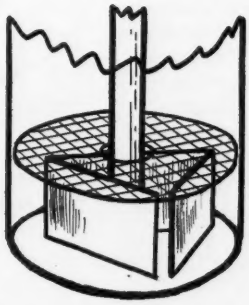


Fig. 1a

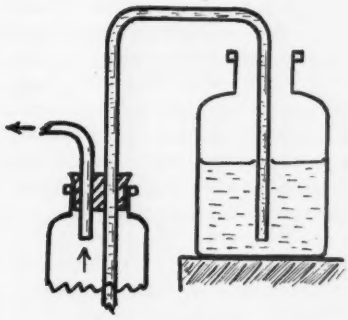


Fig. 5

A cylindrical piece of rubber sponge also was tried (Figure 4), but this was found not to stand up as well as the other materials used.

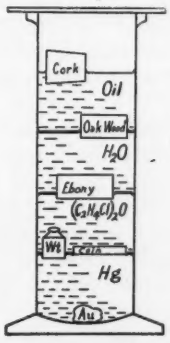
Until the porcelain model is available on the market, however, the copper model (Figures 1 and 1*a*) should prove satisfactory for most purposes. It is simple enough to assemble to permit its distribution for individual pupil use. (Note: it will be found best to use large crystals of the solid reagent, rather than the reagent in powdered form.)

A UNIQUE DENSITY, NON-MISCIBILITY DEMONSTRATION

RALPH E. DUNBAR

Dakota Wesleyan University, Mitchell, South Dakota

THE differences in density of four common liquids, mercury, dichloroethyl ether, water, and oil, the non-miscibility of any combination of these four liquids, and their buoyancy as expressed by Archimedes' principle can be rather conveniently demonstrated by use of the simple apparatus illustrated herewith. A tall hydrometer jar or wide-mouthed bottle makes a suitable container. A cork, piece of oak wood, ebony, brass weight or coin, and piece of gold or platinum will find their positions on the surfaces of the several liquids as illustrated. If a tightly closed container is used the entire contents may be thoroughly mixed, and upon standing each liquid and object will eventually find its correct position, since no two of the liquids used are



miscible one in the other. When once this piece of equipment has been prepared, it may be retained indefinitely for demonstration purposes.

A SIMPLIFIED LABORATORY STIRRER *and* MELTING-POINT BATH

L. S. KEYSER

University of Illinois, Urbana, Illinois

TO MOST students taking the laboratory work in qualitative organic analysis the desirability of having a simple and compact set-up for accurate determination of melting points has real significance. That the use of any device depending on convection currents to accomplish stirring gives rise to errors of order of magnitude up to five degrees is well known, and while the use of a small beaker with hand stirring is less open to criticism, it is inconvenient, to say the least. Various types of stirrers have been proposed, but are for the most part complicated and difficult to make. The stirrer herewith described is capable of operation on either laboratory suction or compressed air supply and possesses in addition the following advantages. It is very simple in construction and has considerable power, so that it may be used for other purposes than melting-point baths. There is no draft of air to blow out the flame or cool off the thermometer. All the parts are either standard laboratory apparatus or can be easily fabricated by anyone.

The drawings are almost self-explanatory, but the following description is given so that any points which might cause confusion may be clear. In Figure 1, *A* is an ordinary thistle tube cut off and carefully fire-polished about two inches from where the small tube joins to the bulb. *B* is a glass rod having any desired length and of such diameter as to just fit the bore of the thistle tube. The fit should be just loose enough so that free turning is possible. (A bit of vaseline makes an ideal lubricant.) *C* and C^1 are rubber stoppers with holes cut as illustrated. *D* and D^1 are small metal washers which serve as bearings and lessen the inrush of air at *D*. The jet *E* is drawn in such a way that maximum turning effect may be obtained. Although only one such jet is shown, others may be put in in a similar fashion. *F* is a small fan cut from sheet metal to fit the opening of the thistle tube. It may be fastened to the glass rod in a variety of ways, but perhaps the simplest is a friction joint. If, when making the hole in the center of the circle from which the fan is to be made, the hole is not bored but punched with a file or other blunt instrument, the small flares of metal left will furnish ample footing for a friction joint with the aid of a small rubber tube or cork, *G*, which serves to hold the fan on the glass rod. *H* is a screw-type blade which is easily made by heating the end of the rod in a flame until soft and then flattening by means of pincers or other suitable tool. After the end is flattened for about a half inch or so, it can easily be shaped in the form of a screw by grasping the end and twisting while the glass is still pliable. This type of blade has the advantage of giving adequate stirring without splashing or frothing and at the same time lessening the danger of breaking a thermometer. The fan should be adjusted so that it rotates in the plane of the maximum diameter of the bulb. The end of the glass rod may or may not be used as a bearing by adjusting the height of the rubber stopper. Actual adjustment of the stirrer will make this point clearer.

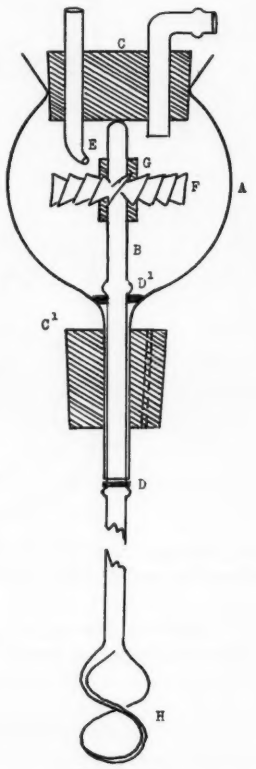


FIGURE 1

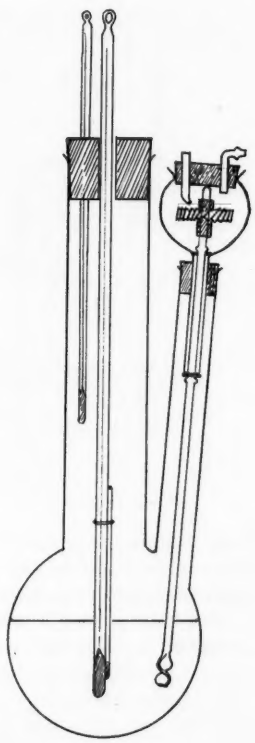


FIGURE 2

The stirrer as described, when properly adjusted, will work smoothly and efficiently. As such it has many laboratory uses and may be preserved as a unit itself or incorporated with a two-necked flask fashioned from a long-necked boiling flask by sealing in a side tube having a bore of about 15 millimeters, as shown in Figure 2, to form a convenient and useful melting-point bath having all the advantages outlined above. One

disadvantage likely to arise in the use of the stirrer with such a flask, unless precautions are taken against it, is that fumes of the liquid of the bath will be drawn up through the thistle tube with resultant complications. This difficulty can be entirely obviated by careful fitting of the bearing at *D*, Figure 1, and by the use of more than one inlet jet. A similar compensation is obtained by increasing the size of the opening in the inlet jet. The stopper C^1 should also have a good-sized slit or a second hole in it to allow the air to be drawn up rather than vapors from the bath medium. If the stirrer is not used in a closed system, these precautions are of course unnecessary.

The use of the two-necked flask has the advantages that it gives an accurate means of getting stem correction, furnishes a compact unit that may be put away in a laboratory desk, magnifies the melting-point tube, and has sufficient volume of bath medium to allow delicate control of the bath temperature. The whole assembly may be fastened to a ring stand by means of a single clamp.

If a two-necked flask such as is shown is not available and facilities for making it are not at hand, a small three-necked flask lends itself admirably to use as a melting-point bath when used in conjunction with the stirrer, or simpler still, a small beaker may be used. The only advantage afforded by the use of a beaker is its ease of changing medium and cleansing. However, if sulfuric acid saturated with potassium bisulfate is used as the medium, the tendency to discolor is not great and changes need not be made very often.

Many modifications of the stirrer here described are, of course, possible. The design of the fan may take almost any form, but in the experience of the writer a simple one having eight blades twisted to an angle of 45 degrees works as well as any. If the reader has trouble getting his stirrer adjusted, his difficulty may lie in the inlet tip. The best angle can usually be found easily by the trial-and-error method. It is not difficult to get one of these stirrers to work, and the little time and effort spent in making one of them will be well repaid in satisfaction gained from service.

THIRD DECEMBER CHEMICAL ENGINEERING SYMPOSIUM OF INDUSTRIAL DIVISION

EACH holiday season has come to be looked upon as the annual time for the Division of Industrial and Engineering Chemistry to hold a symposium of special interest and importance to chemical engineers and those in industries and universities who are dealing with problems bearing upon manufacturing and development.

Two years ago in December at Massachusetts Institute of Technology, an outstanding symposium was held on the subject of "Distillation." A year ago, under the same auspices, a symposium on "Heat Transmission" was conducted at Yale University. The attendance at both of these meetings was very good. Not only were the papers of high merit, but the discussion which followed each was pertinent, timely, and stimulating.

Again this year the Division will hold a symposium. It will be at Columbia University on Monday and Tuesday, December 28th and 29th. The subject will be "Absorption and Extraction." The program is well advanced and definite promises of papers have been received, being equally divided between the two related topics. As has been the practice in previous symposia, the contributors are from both industrial and educational sources. Reports are expected on research done at the University of Birmingham, England, Drexel Institute, University of Illinois, Massachusetts Institute of Technology, Pennsylvania State College, Princeton University, and the University of Virginia, as well as a number of papers from the chemical engineering staffs of leading oil companies and equipment manufacturers.

It is sufficient to say at this time that when the names of the contributors for the final program are announced, no one who has any connection with work relating to absorption or extraction will wish to miss this important symposium. So it is suggested that definite plans be made to attend this meeting by arranging for hotel accommodations at this time. This can be taken care of by writing to J. J. Morgan, Professor of Chemical Engineering, Columbia University, New York, N. Y., or to your favorite New York hotel.

There will be an informal dinner Monday night, December 28th, which will be addressed by a prominent speaker, perhaps a man not in any way connected with chemistry or chemical engineering. There will be luncheon facilities at or near the University during Monday and Tuesday, and all the meetings will be held at Havemeyer Hall, Columbia University.

For several months the committee, consisting of Dr. T. H. Chilton, Professor B. F. Dodge, Professor D. B. Keyes, Professor J. J. Morgan, Professor T. K. Sherwood, and the officers of the Division of Industrial and Engineering Chemistry, have been arranging the details of the program, which will occupy the full two days, December 28th and 29th.

Another reason why you should attend the symposium is that members of your family will enjoy a shopping and theater tour of New York City.

ERLE M. BILLINGS, *Secretary-Treasurer*

CORRESPONDENCE

MASTERY TESTS IN CHEMISTRY

To the Editor

DEAR SIR:

I have just received an advertisement, with sample pages, of Fowler and Kane's "Mastery Tests in Chemistry." I am probably late in emitting this wail, as these tests have apparently been in use for some time. Others may have wailed before me. I hope so.

We have all been brought up to greet with laughter that famous old question, "Who dragged whom how many times around the walls of what?" It is supposed to represent everything that an examination question should not be. And yet here is a set of examinations, or tests, perhaps, where about one question in five is of this type, if the three samples are any criterion. Take the following: An element has 39 protons and 20 electrons in its ---. It is therefore a --- conductor of ---. Without trying to see what the examiner *wanted* the student to answer, let's see a few of the ways that he could have answered it. He could have filled the first blank with either "nucleus" or "nucleus and inner ring" or "nucleus and first two rings," etc. In any of these cases it would have been a "good" conductor of "electricity" or of "heat," or a poor conductor of magnetic lines of force, or if the student wanted to be facetious he could have said that the element was a poor conductor of trolley cars. That would be true.

How about this: Inert elements show no power to - - - or to - - - electrons. As a student I should have been tempted to insert "help" and "harm." That's probably true. The answer the examiner wanted is not true. Radon is an inert gas, and it does lose—no, I take it back—it doesn't lose electrons, but it does lose protons. I had to look that up; what about the poor student?

Then take the following questions, of the "true and false" variety.

1. The gardener makes a practical classification of plants.

2. The botanist makes a natural classification of plants.

The first is all right by me. I'd be inclined to doubt the second, just because true and false questions always put me on my guard. I don't know how "natural" the botanist's classification is. And which botanist, anyway?

3. A practical classification has a fundamental basis, such as similarity in structure.

That sounds reasonable enough, but I know—because I have read the book—that the answer is supposed to be "false."

And there's the crux of the matter. This test is based upon one book. It examines the student on the *words* that he has learned from this book. If he happens to look things up in the encyclopedia or other reference books he can't answer the questions on the exam, because he has learned different words. This type of test penalizes the intelligent student—or would if he weren't intelligent enough to know when to be stupid.

True-false and completion questions require more care in their construction than any other. If they are not painstakingly constructed they show, not the intelligence of the pupil, but the stupidity of the examiner.

Let me close with just one last question: --- is a steel-gray solid, --- is a greenish yellow gas, and --- is a brown liquid. Well, I think that I'd insert "steel," "chlorine," and "bouillon."

And I'd probably be marked wrong.

DANIEL LUZON MORRIS

THE PUTNEY SCHOOL
PUTNEY, VERMONT

To the Editor

DEAR SIR:

I am in receipt of your communication to Ginn and Company referring to our "Mastery Tests in Chemistry."

We are fully aware of the lack of complete objectivity of some of the questions in the "Mastery Tests in Chemistry." In fact, we make no claim as to their "objectivity," "validity," nor "reliability." These words appear nowhere on the tests. We do claim the tests are instructional and help in the "mastery" of chemistry. Since this is the first letter of its kind that we have received in the four years the tests have been in use, we assume our users caught this point which evidently Mr. Morris missed in his critical review. We appreciate the trouble Mr. Morris has taken to read our book, "Chemistry for Today," and to examine the tests and voice his criticism. We would have been still more appreciative of a letter written directly to us rather than to the editor of the JOURNAL OF CHEMICAL EDUCATION. It seems to us that would have been equally effective and equally indicative of a sincere desire to improve the tests. All teachers, as well as authors, should be trying to do their bit to perfect the teaching of chemistry. We all agree there is plenty of opportunity to improve the content, method, and testing program in the teaching of chemistry in high school.

Taking up Mr. Morris' criticism, point by point, may I state:

I. The element in question has 39 protons and 20 electrons in its nucleus; 39 protons, 20 electrons, and 2 additional electrons, in the nucleus and first ring; 39 protons, 20 electrons in the nucleus, 2 additional electrons in the first ring and 8 additional electrons in

the second ring, etc. Undoubtedly, we shall introduce the term "neutron" when the tests are revised. While the other answers might be possible they are not logical, as based upon the statement, and are unscientific.

II. The question refers to *electrons*, not *protons*. Inert elements do not lose electrons, nor gain them.

III. Figures "1," "2," "3" teach a fundamental fact of science. Surely we are not to be criticized unfavorably for that? If an encyclopedia or other books teach differently, they are wrong. A gardener makes a practical classification when he grows tomatoes and sells them on the market as a vegetable. He would be run off the market if he sold them as a fruit, which they are according to the classification of the botanist. A botanist is a scientist. Does our critic mean that the student is stupid if he knows the meaning of practical classification, natural classification, gardener, and botanist?

Mr. Morris states that the tests follow the book and examine the students on the words in the book. That is correct. It is what the tests were intended to do, for the words in the book convey the meanings and understandings we want the pupils to get.

IV. This question is written under a unit entitled, "The Periodic Law; the Halogen and Phosphorus Families." Such answers as proposed by Mr. Morris are illogical, unscientific, and not to be tolerated from pupils in a class in chemistry.

GEORGE W. FOWLER

BOARD OF EDUCATION
SYRACUSE, NEW YORK

SOME ALUMINUM REDUCTION EXPERIMENTS

R. A. KARGES

State Teachers College, River Falls, Wisconsin

MANGANESE dioxide can easily be reduced to metallic manganese with very simple apparatus and very inexpensive materials. Most authors[1] state that this reaction is so violent that the manganese dioxide must first be transformed by prolonged heating in a gas or electric furnace to Mn_3O_4. Even when this lower oxide is mixed with aluminum, the student is directed to start the reaction with only a small portion of the mixture and to add the rest as the reaction proceeds.

We have found that this reaction can be made to proceed smoothly by using aluminum turnings instead of granular aluminum. The manganese dioxide is heated only enough to dry it. Five hundred grams of powdered pyrolusite is heated in an iron dish over a Bunsen flame for 20 minutes. When cool, this is mixed with 185 grams of aluminum turnings. The turnings are cut into about 1-cm. lengths with the tin shears. This labor may be avoided by purchasing the turnings in wide cuttings instead of long stringy pieces. These cuttings can be quickly broken up in an iron mortar. The mixture of manganese dioxide and aluminum is placed in a 5-inch flower pot or an 8-inch clay crucible, embedded in a pail of dry sand. An igniting mixture is made of 10 grams of barium dioxide and 1 gram of aluminum powder. Half of this mixture is worked into the main charge to a depth of about 2 cm. and within a diameter of 5 cm. at the top center of the charge. The rest is put into a hole about 2 cm. deep pressed into the center of the mixture. In this is placed the lower end of a fuse made by wrapping 0.25 gram of powdered magnesium in a piece of tissue paper. This is a much more effective fuse than a piece of magnesium ribbon and much more easily ignited. The ignition and reduction of the charge is, of course, conducted out of doors. Because of the size of the aluminum particles the reaction proceeds at a moderate rate without throwing out the contents of the crucible. When the product has cooled, the slag of aluminum oxide is hammered away and a regulus of metal is obtained. Students in a class in inorganic preparations regularly get a yield of from 70 to 100 grams. Half the above quantities may be used, but the metal is likely to be dispersed somewhat through the oxide instead of forming a single mass. By using an excess of aluminum (100 grams of aluminum to 250 of manganese dioxide) an alloy of lower melting point is formed, which is more likely to form a single regulus.

Another interesting reduction with aluminum is the preparation of crystallized silicon from sand described by Biltz and Biltz (*loc. cit.*, p. 13). Forty-five grams of fine dry sand, 50 grams of powdered aluminum, and 60 grams of flowers of sulfur are mixed and put into a 4-inch clay crucible. A fuse prepared with magnesium powder is embedded about 2 cm. deep in the mixture. The reaction is conducted out of doors; it proceeds rather slowly. When cool, the crucible is broken and the contents placed in a dish of water. There is a violent evolution of hydrogen sulfide due to the hydrolysis of aluminum sulfide. When reaction has ceased, water is run into the dish and allowed to overflow. A firm black regulus of silicon is found in the dish, usually with smaller globules. This may be left in hydrochloric acid for several days, or it may be broken up at once. The inside of the regulus shows shining leaflets of silicon.

[1] BILTZ, H. AND W. BILTZ, "Laboratory methods of inorganic chemistry," translated by W. T. Hall and A. A. Blanchard, John Wiley & Sons, New York City, 1909, p. 12.

W. O. Brooks
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ABSTRACTS

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KEEPING UP WITH CHEMISTRY

German industrial fat. J. Hetzer. *Chem.-Ztg.*, **60**, 405–7 (May 16, 1936).—A survey dealing with the production of synthetic fats by the chemical industry, the recovery of industrial oils and fats from waste waters of the household, cities, etc., and industrial waste waters, the refining of fats and oils, and the production of resins in German forests. L. S.

A bean worth knowing. Anon. *Ind. Bull. Arthur D. Little, Inc.*, **116**, 2–3 (Sept., 1936).—The bean worth knowing is the soy or soya bean discovered some 25,000 years ago and almost unknown in this country twenty years ago. Its cash transactions last fall exceeded those of corn and the number of bushels produced was approximately 40,000,000. This article summarizes the recent soya bean symposium of the American Chemical Society and is a reprint of E. F. Marsiglio's editorial in *The Chemist Analyst* of the J. T. Baker Chemical Co. The soya bean or its products have already found the following uses:

Paints	Stock feed
Varnishes	Breakfast cereals
Plastics	Flour
Glues	Cooking and salad oil
Soaps	Infant diet materials
Auto parts	Meat packing
Rubber substitutes	Beverages
Floor coverings	Candies

The soya bean is a new crop to the farmer. It is said to be chemically beneficial to the soil, ideal for crop rotation, and good for silage. There are many varieties of the soya bean which may be classified as the "food" and the "industrial" types. Soya bean as a food is not used extensively in this country. What relative positions the "big four"—wheat, corn, oats, and soya—will take only time can tell. G. O.

Cast rubber. Anon. *Ind. Bull. Arthur D. Little, Inc.*, **116**, 3 (Sept., 1936).—Rubber is a material of almost limitless possibilities. Casting rubber by the "Kaysam" process has opened up additional possibilities. Rubber casting is but a few years old. It is based on the discovery that thickening agents when added to rubber latex will cause it to set in the form of a liver-like "gel." This can be dried and vulcanized to produce a finished rubber article. The raw material is "Revertex," the highly concentrated form of latex containing 60 to 65% of rubber and other solid ingredients, and yet it has the consistency of whipping cream. Synthetic rubber or "Duprene" may even be used. The process originated in England mostly for the making of bathing shoes and toys, but it is having its greatest development in this country. A rubber pail called "Darex" has already reached commercial production. Meteorologists are interested in the cast rubber balloons. One size of balloon has been designed to carry apparatus up into the stratosphere and has already established an altitude of 100,000 feet. G. O.

Ammonium bicarbonate as a gas plant by-product. C. H. S. Tupholme. *Ind. & Eng. Chem., News Ed.*, **14**, 370 (1936).—A report of progress made in studying the use and manufacture of ammonium bicarbonate in England. The CO_2 and NH_3 in equal amounts are removed from the ammoniacal liquor and washed in a saturated solution of ammonium bicarbonate. The crystalline bicarbonate is removed and stored for use. The excess NH_3 in the ammoniacal liquor is mixed with more CO_2 and fed back to the distillation column and mixed with the crude liquor. The tests indicate that the ammonium bicarbonate can be produced as cheaply as ammonium sulfate. Experiments are in progress to determine the value of ammonium bicarbonate as a fertilizer. The main difficulty is to prevent the loss of NH_3 or the injuring of the plant by this free ammonia. There is evidence that it can be successfully used, but care must be taken to prevent trouble from this characteristic of the salt. A. A. V.

The food engineer. W. W. Moss. *The Chemist*, **13**, 455–63 (Mar., 1936).—A new field—broad in scope—new and promising, presents to the qualified chemist an exceptional opportunity. A new term has been proposed—namely, that of "Food Engineer." This new field functions as a liaison between the less tangible food chemistry and the more practical industrial applications of food chemistry. As a cognate of food chemistry, food engineering expresses food chemistry and technology in terms of practical production, thereby enhancing the commercial worth of food chemistry and the food chemist.

Conditions in recent years have shown the food manufacturer's need of a food manager. Where could he find such a man? What are the qualifications of such a specialist? The amount of chemical training required for the food engineer is that prerequisite for the food chemist. Basic training should include a knowledge of food factors, including vitamins, etc. Several years of personal food research are necessary in order that the food engineer may have a first-hand understanding of food constituents.

General engineering knowledge is of great importance. Specifically, food engineering has its foundation in (1) unit operations and (2) unit processes. The entire food manufacturing field may be reduced to fifteen groups or unit operations as follows:

1. Cleaning
2. Coating
3. Controlling
4. Cooling
5. Decorating
6. Disintegrating
7. Drying
8. Evaporating
9. Forming
10. Material handling
11. Mixing
12. Packaging
13. Pumping
14. Separating or concentrating
15. Storaging

A food engineer should be able to step into any food plant and take charge, once he has studied the flow-sheet of that plant and reduced it to "unit operations" or "unit processes." A most important function of the food engineer is, of course, to effect economies in the plant.

It can readily be seen that the food engineer can cross-index the food manufacturing field, reducing it to the simplest unit operations and unit processes, to the end of improving his own plant by borrowing from similar unit operations or processes, or to equip himself to fit profitably into any food plant. While this field of specialization is entirely new, it offers a tremendously appealing future to the executive type of trained food chemist with many years of practical experience and with a fair knowledge of the principles of chemical engineering. A. A. V.

The chemist in warfare. L. C. Elmore. *The Chemist*, **13**, 499–505 (Apr., 1936).—The use of chemicals in warfare has developed greatly within recent years. The U. S. Chemical Warfare Service was created on June 28, 1918. The organization includes Office of the Chief of the Chemical Warfare Service, Edgewood Arsenal, Maryland; the First Chemical Regiment and detached companies; the Edgewood Chemical Warfare Depot; the Chemical Warfare Board; the Chemical Warfare School; procurement districts; units of the organized Reserves; two units of the Reserve Officers Training Corps; and officers detailed as additional members of the General Staff.

The work assigned to the C. W. S. is to put into practical application the chemical agents issued for combat and to instruct members of other branches of the service in protective measures against chemicals.

The following facts are pertinent.

1. Chemical agents are greatly influenced by weather conditions. Wind is most important. No enemy can launch a cloud gas attack effectively if the wind is blowing toward them.
2. Clouds have an important effect, especially on non-persistent gases.
3. Heavy rains wash away and destroy persistent agents.
4. Humidity and pressure have practically no effect on persistent gases.

Classes of agents used by the Chemical Warfare Service are based upon: physiological effect; tactical employment; per-

sistency; physical state under ordinary conditions. They include lung irritants; vesicants or gases which burn the tissues; lachrymators; sternutators or gases which produce violent sneezing or coughing; and screen smokes, which produce no physiological effect.

In tactical employment there are four classes:

(*a*) Casualty agents—produce injury or death.
(*b*) Harassing agents—force donning of masks—slow up the enemy.
(*c*) Screening agents.
(*d*) Incendiary agents.
(*e*) Non-lethal agents.

Certain specific requirements which must be fulfilled by chemical compounds which the C. W. S. uses are:

1. Must be highly toxic.
2. Vapor density must be greater than air.
3. Must be easily compressed and readily vaporized.
4. Must be capable of manufacture on a large scale.

A. A. V.

The soy bean goes to town. F. THONE. *Sci. News Letter*, **30**, 74–6 (Aug. 1, 1936).—A special research center for investigating the properties and processing of soy beans has been opened at the University of Illinois. This plant has already been naturalized in America but its versatility for American consumption is not yet abreast with its use in China. A beginning has been made in its use in plastics; the large proportion of the seed, 65%, which is oil usable in paints invites consideration, and its worth as a stock food by American feeders has possibilities. Whether the human appetite of Americans can be cultivated for soy bean dishes is yet to be tested. Chemically speaking, the variety of food elements in the bean should be attractive to the nutrition experts. B. C. H.

Food for the land. F. THONE. *Sci. News Letter*, **30**, 90–2 (Aug. 8, 1936).—There are many foods for land. This particular paper tells what has been done under TVA to process phosphate rock and turn it into "triple-superphosphate." Use is being made of furnaces of plant number 2 of Muscle Shoals for reducing the phosphate compounds to elementary phosphorus. By manufacturing phosphoric acid from the element and then "triple-superphosphate" in place of the common superphosphate prepared by use of sulfuric acid the phosphorus content of the resulting fertilizer has been increased from 7 to 28%. Other uses of phosphorus are suggested. B. C. H.

Waste lactose is raw material for a new lactic acid process. T. R. OLIVE. *Chem. & Met. Eng.*, **43**, 480–3 (Sept., 1936).—One phase of the assistance that the farmer is receiving from chemistry and chemical engineering is the production of chemical materials as by-products of the dairy industry. One of the big problems is to find an outlet for the summer surplus of milk as well as the skim milk from which cream has been removed. Some whey is being converted into lactose, but much of it is still wasted. It has been found that by use of a mixture of a lactobacillus, such as *L. bulgaricus* or *L. casei* and a mycoderm, the lactose of the whey can be converted into lactic acid. This is now carried out on a commercial scale. The lactic acid formed is converted by liming into calcium lactate. This may be purified to give a high-grade product or converted back to lactic acid by the addition of sulfuric acid. J. W. H.

Yeast, physiology, manufacture and uses. CHARLES N. FREY, GEORGE W. KIRBY, AND ALFRED SCHULTZ. *Ind. Eng. Chem.*, **28**, 879–84 (Aug., 1936).—In the highly mechanized industries in which yeast is used, the processes are so timed that it is almost necessary for the yeast to act as a chemical compound, with a constant and uniform fermentation rate from day to day. The main food requirements in addition to sugars are, N, P, and K. N is furnished as ammonia and the additional P requirements are met with phosphates which also act as buffers. The energy requirements and the aërobic and anaërobic conditions of growth of yeast and fermentation are discussed. At 30° under most favorable conditions yeast will double its weight in slightly less than two hours. The Hayduck, or modern process of yeast production, is described, as well as the production of yeast of high vitamin content.

About 230,000,000 lb. of yeast are produced annually, most of which is used in bread making, brewing, and as a source of vitamins. D. C. L.

Improved electrolytic method of sodium production. ANON. *Chem. Industries*, **39**, 269–71 (Sept., 1936).—A modified method for the electrolytic production of the alkali and alkaline-earth metals, especially metallic sodium, has been worked out by I. J. Moltkehansen, of Brussels. Invention consists of a process for the production of those metals by electrolysis of fused salts thereof in which electrodes of a metal other than the metal to be produced are employed. Another feature is the use of diaphragms for the separation of anodic and cathodic products, characterized by the provision in the electrolytic cell of a combination of two salts or compounds of the metal to be produced, one of which is initially decomposed by the electrolysis, and the other of which reacts with the initial anodic products to set free inert products and to reconstitute the substance initially decomposed.

According to one part of this invention described in the British specification, fused sodium hydroxide is electrolyzed in the presence of fused sodamide, by which the water formed according to reactions (1) and (2) below is fixed with liberation of ammonia, according to reaction (3).

$$\begin{array}{lll} & + & - \\ (1)\ NaOH & = Na & + OH \\ (2)\ 2OH & = H\,O & + {}^1/_2O_2 \end{array}$$

$$(3)\ H_2O + NaNH_2 = NaOH + NH_3$$

The process of electrolyzing caustic soda in the presence of sodamide is claimed to be advantageous in that the melting point of the electrolytic bath is very much lowered and the secondary reaction between sodium and water at the cathode with formation of hydrogen is suppressed, and thus all danger of explosion is avoided. Suppression of the danger of explosion permits the construction of totally enclosed large units with perfect safety. Consumption of current necessary to maintain the bath in a state of fusion is reduced, and the number of kilowatt-hours consumed for each kilogram of sodium produced in the metallic state is correspondingly reduced. A. T. B.

Gypsum as a chemical raw material. J. S. OFFUTT. *Chem. Industries*, **39**, 252–65 (Sept., 1936).—Under the lash of wartime necessity, Germany utilized gypsum as a much needed source of sulfur for the manufacture of sulfuric acid. Her limited pyrites deposits were low in sulfur and difficult to use. Unable to secure sulfur from other countries because of naval blockade, she quickly developed and built a plant where gypsum was mixed with shale and burned in a rotary kiln. Cement was formed from the clinker and the sulfur dioxide was made into sulfuric acid. This undoubtedly is the most advanced chemical use of gypsum to date.

The most important chemical uses of gypsum, where it intimately enters into chemical reaction, are as follows: cement retarder, land plaster or fertilizer, water treatment, calcium sulfide production, glass, neutral, inert drying agent, source of lime and sulfur, and in ammonium sulfate manufacture.

Though it contains only 18.5 per cent. sulfur, because it is found in vast deposits throughout the world gypsum can be considered one of the world's great potential sources of sulfur. In the United States the chemical utilization of gypsum has been small, largely because of the great deposits of pure sulfur available in Louisiana and Texas. While iron pyrites contains about twice as much sulfur as gypsum the deposits are not nearly so extensive. Germany demonstrated to the world some of the chemical possibilities of gypsum. At some future date, should the supply of pure sulfur fail, then gypsum, as a chemical raw material, will receive a great deal of consideration. A. T. B.

Meet the adhesives. C. F. MASON. *Chem. Industries*, **39**, 59–61 (July, 1936).—Constant introduction of new synthetic and modified natural materials in various forms into home and industrial utensils carries with it the necessity of adhesives for repairing broken parts and attaching such materials either to themselves or to others. These problems are still being solved by largely empirical methods with satisfaction, though little effort has been made to place adhesives upon a strictly scientific basis from the point of view of methods of application, time of drying, strength of bond, and the mechanism of the phenomena of cohesion and adhesion.

Practical methods have resulted in the accumulation of over one thousand published formulas under the general headings of glues, mucilages, pastes, cements, binding materials, calking compounds, and sealing compositions, with the briefest directions for formulation, and use in specific cases. One hundred and thirty patents have been granted in this field in the past thirty years with considerable activity in late years, especially in patenting synthetic materials like resins, and their plasticized modifications for adhesive purposes.

The principal causes of failure in joints are insufficient drying, discontinuous films, films of varying thickness, and bubbles. The last three factors can be controlled by careful application, but the first requires time even with forced drying, which is questionable in many cases. The fact that it requires three weeks for gelatin to dry, when pressed between two metal discs three-quarters of an inch in diameter, proves that imperfect drying is the major reason for failure of specific joints. A. T. B.

HISTORICAL AND BIOGRAPHICAL

Robert Wilhelm Bunsen on the occasion of his 125th birthday. G. W. FELDHAUS. *Chem.-Ztg.*, **60**, 265–6 (Mar. 28, 1936).—Bunsen's biography on the occasion of his birthday, March 31st. L. S.

André Marie Ampère, 1775–1836. D. MCKIE. *Nature*, **137**, 934–5 (June 6, 1936).—France has recently observed the centenary of Ampère's death with a commemorative stamp and an exhibition in Lyons, his birthplace. Even as a child, Ampère showed remarkable aptitude for mathematics. For an entire year, however, after his father fell victim to the Revolution, his brilliant mind was unable to function normally. The reading of Rousseau's "Letters on botany" restored his interest in science. His first contribution was on the mathematical theory of games of chance. His classical researches on electrodynamics followed immediately upon Oersted's fundamental discovery that an electric current affects a magnetic needle. Ampère discovered "the laws governing the deflection of the magnetic needle with regard to the current and the mutual attractions and repulsions of electric currents." He "devised astatic needles, formulated the well-known 'Ampère's Rule' for determining the deflection of a magnet by an electric current, suggested the electric telegraph as an application of Oersted's discovery. . . and was opposed to the caloric theory. . ." M. E. W.

Bicentenary of Coulomb (1736–1806). ANON. *Nature*, **137**, 976–7 (June 13, 1936).—Charles Augustin de Coulomb was born on June 14, 1736, and was a contemporary of Laplace, Lavoisier, Monge, Charles, and Berthollet. His most important researches dealt with mechanics and electricity and magnetism. His first paper presented to the Academy of Sciences in 1773 dealt with the strength of building materials. In his seven memoirs on electricity and magnetism published between 1785 and 1789 he described the torsion balance "and enunciated the laws of attraction and repulsion in electricity and magnetism." Poisson later founded his mathematical theory of electricity on the data in these papers. M. E. W.

Exhibition of historic scientific apparatus at Cambridge. ANON. *Nature*, **137**, 977 (June 13, 1936).—The Cambridge Philosophical Society, with the help of Dr. R. T. Gunther of Oxford, has collected old apparatus used by famous Cambridge scientists. The collection includes series of instruments showing progress in the design of electrometers, electroscopes, galvanometers, air pumps, slide rules, microscopes, and microtomes. The microscopes of Charles and Erasmus Darwin are included. M. E. W.

Centenary of the death of Dr. William Henry, F.R.S. ANON. *Nature*, **138**, 376 (Aug. 29, 1936).—On September 2nd of this year occurred the centenary of the death of Dr. William Henry (1774–1836). He was a pupil of Joseph Black and a friend of John Dalton. Henry's "Elements of experimental chemistry" was an accurate, well-written book which went through eleven editions. His contributions to science include his famous experiments on the absorption of gases by water, papers on medical subjects, and biographical sketches of Priestley, Davy, and Wollaston. A biography by his son, Dr. W. C. Henry, is mentioned. M. E. W.

Sir Henry Wellcome, F.R.S. ANON. *Nature*, **138**, 275–6 (Aug. 15, 1936).—Sir Henry Wellcome, archæologist, explorer, chemical manufacturer, and philanthropist, died July 25, 1936, at the age of eighty-two years. He was born in Wisconsin and studied pharmaceutical chemistry in Chicago and Philadelphia. He traveled extensively in North and South America. He had a lifelong interest in cinchona, and in 1930 he organized the London tercentenary celebration of its discovery. In 1880 he and the late Mr. S. M. Burroughs established the very successful firm of Messrs. Burroughs, Wellcome and Co. for the manufacture of chemical and pharmaceutical products. In 1894 Sir Henry founded the Wellcome Physiological Research Laboratories and two years later the Wellcome Chemical Research Laboratories. The Wellcome Bureau of Scientific Research was founded in 1913.

"By the death of Sir Henry Wellcome, the world loses not only a great, but also an effective giver. . ." M. E. W.

EDUCATIONAL MEASUREMENTS AND DATA

Questionnaire study of student expectancy from a course in general chemistry. R. E. DUNBAR AND L. TUSSING. *Sci. Educ.*, **20**, 75–7 (Apr., 1936).—This was a questionnaire study involving 39 college students and 73 high-school students in Mitchell, South Dakota. General conclusions from the study were: (1) as a general rule the knowledge expected to be gained by a high-school student and a college student is the same; (2) a large number of students are taking chemistry as a basic foundation for some other course or vocation; (3) another large portion is expecting to get some skill in qualitative analysis; (4) a surprisingly large number of boys, both high-school and college, were studying chemistry for cultural values, enlarging vocabulary, appreciation of chemical surroundings, etc.; (5) girls seem to be the only ones interested in household helps or the processing of food products. C. M. P.

What factors make for good or poor achievement in science? A. W. HURD. *Sci. Educ.*, **20**, 4–7 (Feb., 1936).—This is a résumé of an experimental study reported at the Atlantic City meeting of the N.A.R.S.T. A test was given to pupils in a group of coöperating schools using an experimental unit in physics, "Sound, Music, and Hearing." Forty comparisons are made. The general conclusion was: "A dynamic attitude on the part of the pupil, an interest in the kind of work represented, both constituting motivation; a good teacher; natural mental ability sufficient for the work; the possession of character trait ratings above the average on such traits as originality, industry, self-reliance, systematization, and consciousness; all these make for high achievement on the instructional unit in this experimentation." C. M. P.

PROFESSIONAL

"The four horsemen" create jobs for chemical engineers. J. H. PERRY. *Chem. & Met. Eng.*, **43**, 439–40 (Aug., 1936).—The Four Horsemen of the Apocalypse—Fire, Famine, Pestilence, and Death—the Biblical scourges of ancient times, have their counterparts and parallels in the process industries. Losses by fire are still large and much remains to be done in this field. Defining famine as "an extreme scarcity of a material or thing" leads it to include raw materials, labor, water, power, fuels, transportation facilities, markets, etc. Pestilence is represented by a large number of hazards, nuisances, dangers, and sources of reduced profits. Death includes not only health hazards, but economic health as well. Men who enter any of these fields have ample opportunity to use their technical information. J. W. H.

Chemical engineering from a world view. VISCOUNT LEVERHULME. *Chem. & Met. Eng.*, **43**, 416–7 (Aug., 1936).—The chemical engineer has been defined as a "man experienced in the design, construction, and operation of plant and works in which matter undergoes a change of state and composition." This brings out the fact that he is first and foremost an engineer, although his need for chemical knowledge arises from the fact that the plant he constructs is required to handle materials upon which it will, chemically speaking, have some effect and which will, in turn, be affected by them. Chemical engineering has developed as a direct answer to the demands of industry. To the layman the chemical engineer manifests himself as the guardian of his health and his pocket. Chemical engineering, by whatever name it may be called, is today practiced all over the world and occupies a position of prime importance in our world economy. J. W. H.

How wide is the gap between principle and practice. W. A. MCCALL. *Teachers Coll. Rec.*, **37**, 603–6 (Apr., 1936).—Evidence is accumulating that the gap between principle and practice is much wider than has generally been supposed and is too wide to justify much of the teacher training given in normal schools and teachers' colleges. Principles, to be of real help, must be embodied in functioning procedures. Little by little, in certain areas, the gap is being bridged between principle and practice, precept and example. C. M. P.

RECENT BOOKS

PHYSICAL ASPECTS OF ORGANIC CHEMISTRY. *William A. Waters*, Lecturer in Chemistry, University of Durham; introduction by *T. Martin Lowry*, Professor of Physical Chemistry, University of Cambridge. D. Van Nostrand Company, Inc., New York City, 1936. xv + 501 pp. 13.5 × 21.5 cm. $9.50.

It will be generally agreed that in presenting this account of the electronics of organic structures and reactions, Mr. Waters has performed a useful service for organic chemistry. The period since the introduction of the electronic interpretation of valence has been an active one for organic theory, but whether because of the rapidly changing state of uncertainty that has been characteristic of the theory, or for some other reason, there have been few books which have attempted to go beyond a limited number of highly specialized applications. As a matter of long established practice, the writers of textbooks on organic chemistry avoid theoretical matters with great care, and the mass of experimental observations is spread out, in such works, in a manner which might be likened to a map without a coördinate system. This method of presentation has the great virtue that the material may be arranged for its artistic value, but, however satisfying this may be, the student can hardly fail to be aware that progress along theoretical lines is taking place and his only recourse has been the original literature. The volume at hand, written with the intention of giving a general outline of theoretical organic chemistry, thus occupies a unique position at this time and is bound to stimulate fresh interest in fundamental problems of organic chemistry.

Mr. Waters makes a clear distinction between ionic and non-ionic reactions. Concerning the former, it is his opinion that there has at last emerged a consistent electrochemical theory of organic reactions, and the major part of his book is devoted to an elaboration of this thesis. Non-ionic reactions are dealt with summarily in a chapter on free radicals. The first part of the book includes also chapters on chemical affinity, physical theories of molecular structure, valency, electrical dipoles, chemical reactivity, and unsaturation.

The electrochemical theory referred to is, of course, that to which Mr. Waters himself has lately been contributing, and with which are associated, among others, the names of Lapworth, Ingold, Robinson, and Lowry. It deals, as there is little need to mention, with the mechanism of the polar activation of organic molecules, presupposing that such activation is the essential feature of reactions which take place in solution and under the influence of ionized reagents. Among the subjects discussed in this connection are the following: acidity, reactivity of halogen compounds, general polarity, hydrolysis and esterification, ionotropic change, molecular rearrangement, conjugation, and the structure, substitution, and reactivity of aromatic compounds. Since nothing of a predictive nature is attempted, a pragmatic evaluation of the theory in its present form is scarcely possible.

The book is well documented with references to original papers as well as reviews and other works. With a very few exceptions the references are dated prior to 1935, and thus, while the earlier papers on resonance theory are mentioned, this strictly modern theoretical development does not receive a great deal of attention.

The introduction by Professor Lowry is excellent.

W. G. BROWN

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COLORIMETRIC METHODS OF ANALYSIS, VOLUME I. Inorganic. *Foster Dee Snell*, Ph.D., and *Cornelia T. Snell*, Ph.D. Second edition (greatly enlarged). D. Van Nostrand Company, Inc., New York City, 1936. xxiii + 766 pp. 37 tables. 109 figs. 15 × 23 cm. $9.50.

This work is the second edition (first edition by Foster D. Snell, Van Nostrand, 1921); the objectives are essentially unaltered. The material has been greatly enlarged and extended to include some turbidimetric and nephelometric methods. The descriptions of apparatus have been enlarged but are not claimed to be comprehensive. The first volume covers inorganic colorimetric analysis. It is intended as a reference work to which students may refer for a knowledge of practical colorimetric methods. Also, it is a source to which practical analysts may refer for information as to the methods available in the case of particular demands. The work is not intended as a laboratory and teaching text nor is it intended for reference work only. Critical estimations and evaluations, where a choice is permissible in the case of alternative procedures, have been avoided by the authors. Opinions based upon literature citations are, however, included. Theoretical treatments at appropriate points in the development of subject matter have not been avoided nor have they been overdrawn. Colorimetric technic or calculations have not been stressed. The volume appeals to those familiar with analytical technic, well versed in the theory of analysis, and appreciative of sources of information which are comprehensive, concise, critical, and practicable.

The first nine chapters deal with classification of methods, definitions of terms, theoretical considerations, discussion of accuracy, and types of standardization. The description of apparatus in this portion of the material follows the usual classification into the four groups, series liquid standards, solid standards, dilution and duplication, and the more comprehensive balancing methods. One hundred pages are devoted to this portion of the work.

The following 53 chapters (559 pages) deal with the description of practical methods for analysis of 37 metals and 27 non-metals and non-metal compounds and anions. The elements most extensively treated are copper and cadmium (35 pages), phosphorus (35 pages), arsenic (26 pages), and iron (30 pages).

The last 4 chapters (57 pages) deal with colorimetric hydrogen-ion determinations. This section is not extensively developed but is none the less an important and valuable addition to the work. It will appeal to those making their first explorations in this field, as the material has been well chosen and artfully presented.

The authors have made a distinctly valuable contribution to the field. A volume on this subject is timely and it has been brought up to date surprisingly well. There are approximately 1700 references to the literature of the subject appropriately arranged to indicate their application to the various subject branches.

Nothing can be found seriously calling for criticism. It might be an improvement to avoid repetition of literature references; for example, Chapter XVI, references 29, 46, and 63. Halftone cuts, it seems, have been undesirably reduced in size. The cheaper types of balancing colorimetric equipment should be made to include the Bock-Benedict colorimeter. The drawings have been rather well done and the reduction for reproduction is satisfactory. Figures 42 and 105 are essentially duplications. Misprints and typographical errors are few (calorimeter for colorimeter, page 29, is an example).

One notable improvement could be made in the discussion of practical methods. The material on manganese (Chapter XXIV) states that the standard method for this determination as shown in the 1925 edition of "Standard Methods of Water Analysis" of The American Public Health Association was the bismuthate and persulfate method. The 1933 edition gives as standard methods the persulfate and periodate procedures. It has been demonstrated that the periodate method is much to be preferred. A reference to the latest edition of the Standard Methods would have included this correction.

This volume has been creditably printed, is pleasing and restful to the eyes, the binding is excellent, and arrangements splendidly executed. It might have been better to reduce the weight of paper used and it would be more in keeping with present trends to keep the cost down to a penny per page. Chemistry teachers, advanced students, research analysts, routine

analytical laboratories, and reference libraries will be amply repaid by acquiring possession of this splendid work. The authors are to be congratulated in the completion of a difficult and laborious task artfully done.

G. FREDERICK SMITH

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DISTILLATION. *Joseph Reilly*, Professor of Chemistry, National University of Ireland. Foreword by *Sydney Young*. The Chemical Publishing Company of New York, Inc., New York City, 1936. viii + 118 pp. 41 figs. 10.5 × 18.8 cm. $1.25.

The Chemical Publishing Company of New York, Inc., is exclusive agent in North and South America for this interesting book on the various methods of distillation. The first chapter contains a good review of the mathematics of distillation. The second chapter deals with fractionating columns, and the succeeding two chapters describe methods for the production of low pressures and for carrying out vacuum fractionations. The other subjects treated are the distillation of azeotropic mixtures, steam distillations, destructive distillation, and sublimation. The material is largely taken from recent articles in English and American publications. The treatment is direct and well planned throughout but the chapters and fractionating columns and vacuum fractionations deserve special mention. The material covered makes this small book well worth while for those interested in the theory as well as the practice of distillation. It should be of interest to the teacher of physical or organic chemistry and of value to the student in the laboratory.

ARTHUR A. VERNON

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INDUSTRIAL CHEMICAL CALCULATIONS. *O. A. Hougen*, Ph.D., Associate Professor of Chemical Engineering, University of Wisconsin, and *K. M. Watson*, Ph.D., Chemical Engineer, Universal Oil Products Co., Chicago. Second edition. John Wiley & Sons, Inc., New York City, 1936. ix + 487 pp. 98 figs. 16 × 23 cm. $4.50 net.

This timely book setting forth "the application of physicochemical principles and data to problems of industry" should become popular in both educational institutions and industrial establishments. There are fourteen chapters and an appendix, as well as author and subject indexes.

The chapter headings are Weights and Compositions; Stoichiometry; Ideal Behavior of Gases; Vaporization and Condensation; Thermophysics; Thermochemistry at Standard Conditions; Thermochemistry of Industrial Reactions and Fuels; Weight and Heat Balances of Combustion Processes; Weight and Heat Balances of Chemical and Metallurgical Processes; Crystallization, Adsorption, and Distribution; Compressibility of Gases; Entropy and Free Energy; Fugacity and Thermal Properties at High Pressures; Chemical Equilibria.

In the period of five years since the appearance of the first edition [see J. CHEM. EDUC., 9, 605 (1932)] the authors have recognized the necessity of amplified and, in many instances, changed approaches to chemical engineering principles. "The Thermodynamic approach to problems involving non-ideal conditions has been advanced. . . . This has led to the introduction. . . of concepts of entropy, free energy, fugacity, and activity . . ." Thermodynamic methods have been substituted for the kinetic-theory treatment of equilibrium principles, bringing about "a complete reorganization of the text." The chapter on Weights and Compositions is new.

Study and use of the text is made attractive through the plan of having each chapter somewhat more complex than the preceding ones; also by grouping in Part I such matters as may be treated by algebraic methods, and in Part II so-called "new-ideal cases" subject matter which require the use of the calculus.

The numerous graphs are clear and of sufficient size to make them of genuine service. Typographic and other errors are few, if any. The publishers have done their job well also.

FRIEND E. CLARK

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THE CHEMISTRY OF THE COLLOIDAL STATE. *John C. Ware*, Sc.M., Ph.D., consulting chemist; formerly Associate Professor of Chemistry in New York University. Second edition. John Wiley & Sons, Inc., New York City, 1936. xvi + 334 pp. 96 figs. 15 × 23 cm. $3.75.

This is essentially a textbook for an introductory course in colloidal chemistry, the first edition of which appeared in 1930. "Many practical applications of the colloidal state have been interwoven with the theoretical material."

The scope of the book and its order of treatment may be judged from the chapter headings: The Units of the Colloidal Solution; Sedimentation; Interfacial Phenomena (Non-Electrical); Adsorption; Turbidity in Colloidal Suspensions; Colloidal Suspensions and Color; Motion in Colloidal Suspensions; The Electrical Character of Interfacial Phenomena; The Preparation of Substances in the Colloidal State; The Precipitation of Substances in the Colloidal State: Stabilization or Protection of the Colloidal State; Water in Combination. Viscosity and Plasticity of Colloidal Suspensions; Emulsions; Gels; Silica Gel and Its Use in Adsorption; Intermediate Cases. Soaps; and Catalysis by Contact. No new illustrations have been added.

The order of presentation is the same as that in the first edition but "the space given to adsorption has been doubled, and the subject now occupies an entire chapter. A section on electrokinetic potential has been added to the chapter on the electrical character of interfacial phenomena. The chapter on the precipitation of colloids has been revised and extended to include the recently developed material on the subject. A new chapter has been added on intermediate cases and soaps."

To write an elementary textbook on so vast a subject is no small task and naturally there will be differences of opinion both as to content and as to order of treatment. The reviewer would prefer to discuss the classical work of Thomas Graham and dialysis near the beginning, instead of near the middle of the book (page 131).

On page 68 the statement is made that "in adsorption, if the process is allowed to continue for twenty minutes it may be assumed to be complete." This is not always true.

On page 72 the interesting statement is made that "during the World War, a gas-mask charcoal was found that had an exceptional adsorbing ratio. Elaborate experiments were performed with samples of charcoal in which the porosity, type of pores, and all other features seemed to be perfectly duplicated and yet the adsorbing power did not equal that of the original. It was finally discovered that the material from which the gas-mask charcoal had been made had been soaked in a certain chemical before the charring process, and the presence of the chemical in the resulting charcoal gave it the great efficiency." Unfortunately, the name of the "chemical" is not given.

On page 106 the author mentions that "the value of nephelometer [nephelometry] in research work and in the more general analytical operations is becoming increasingly important. T. W. Richards and others have used the method with great success." Actually, Richards (1894 to 1905) used the nephelometer simply as a means of making small corrections in certain atomic weight determinations and not as an analytical method. It was not until 1912 that Kober, and independently Bloor (1913), showed that nephelometry could be made sufficiently accurate for quantitative analyses.

In addition to the summary at the end of each chapter, a brief list of selected references for further reading would have been helpful, especially for the more advanced students.

Most of the errors, typographical and otherwise, in the first edition have been eliminated. The printing and binding are excellent and the frontispiece, in colors, illustrating several phenomena of the colloidal state (gold sols, Liesegang's rings, etc.), adds to the attractiveness of the book. As an introductory textbook, the new edition will be welcomed by teachers of colloid chemistry.

JOHN H. YOE

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UNIVERSITY, VIRGINIA

DAS AUSBLÜHEN DER SALZE (The Efflorescence of Salts). *Karl Schultze*, Hygienic State Institute of Hamburg. First edition. Theodor Steinkopff, Dresden and Leipzig, 1936. ii + 99 pp. 36 figs. 15.5 × 23.5 cm. $1.60 net.

This book is by no means a new textbook, but rather a compilation of researches which have been made upon the subject of efflorescence. The author has done an excellent piece of work in including so much accurate material within a relatively small number of pages. While the publication is of an introductory character, the material therein constitutes a comprehensive survey of efflorescence and its many applications.

The volume is divided into seven topical divisions as follows:

1. Variety of Names and Early Writings
2. Efflorescence in Soils
3. Climate and Micro-climate
4. Efflorescence of Building Materials
5. Researches Directed toward an Understanding of the Mechanism of Efflorescence
6. Capillary Theory of Efflorescence
7. Influence of Dispersion

In the book the author discusses in meticulous detail the various aspects of the subject and brings the available information relative to efflorescence up to date. To supplement the theoretical discussion, the publication is adequately illustrated with both line drawings and photographs, all of which are carefully and accurately made. Throughout the volume, careful attention is given to the continuity of reference material.

In the opinion of the reviewer, the author has succeeded very well in his attempt to treat the subject of efflorescence in a comprehensive manner. It is recognized, of course, that it is not possible to treat every phase of the subject in equal detail within such a comparatively small number of pages. The author, therefore, deserves credit for the fine publication.

As previously stated, the book is not intended for use as a text, but rather as a source of reference material for anyone engaged upon a piece of research which may involve efflorescent materials and their behavior. The completeness of references is deserving of mention inasmuch as there is a total of one hundred sixty-three references tabulated at the end of the descriptive material. Their selection shows a wide acquaintance with the prevailing literature on the part of the author.

From the standpoint of chemical education, the reviewer wishes to compliment the author and commend the volume to the attention of the research worker.

R. K. CARLETON

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FUNDAMENTALS OF QUALITATIVE CHEMICAL ANALYSIS. *Roy K. McAlpine*, Ph.D., and *Byron A. Soule*, Sc.D., University of Michigan. D. Van Nostrand Company, Inc., New York City, 1936. ix + 325 pp. 3 figures and 12 tables. 15 × 23 cm. $2.40 net.

This unusually well written book is suitable for the second-semester course in college chemistry in which qualitative analysis is presented. In Chapter I is presented some timely review material which includes a list of simply stated definitions. Chapters II, III, and IV treat the topics Chemical Arithmetic, Formulas and Equations, and Ionization Theory in Analytical Processes, respectively. In Chapter V are described in detail several important laboratory manipulations, *viz.*, precipitation, addition of a reagent, folding and fitting a filter paper, filling funnel stem with water, washing precipitates, and removing precipitates from filter paper. Also, directions for several preliminary experiments are given.

Chapter VI treats the lead, silver, mercury (ous) group. First, common compounds and reactions are described. Second, the precipitation of the group is described. Third, directions for the separation and identification of the cations of the group are given. Next follows a critical review of considerations involved in evaluating observations made and the proper use of these observations in reporting the group. This is followed by an excellent discussion on the relation of the group to other cation groups. At the end of the chapter is to be found (1) a list of equations, (2) a summary and review, and (3) a list of problems and laboratory exercises. The remainder of the cation analysis is treated in a similar manner in Chapters VIII to XIII inclusive. The treatment should be valuable to both the student and instructor. What is ordinarily cation group III is divided into two parts, the first part including iron, chromium, and aluminum and being designated as group III, and the second part including zinc, manganese, cobalt, and nickel, and being designated as group IV. It would seem more convenient to designate these two groups as IIIa and IIIb. The greatest deviation from usual practice is a separate treatment of the arsenic, antimony, and tin group, which may be omitted or included as desired.

Chapters XIV and XV treat the identification of some simple acid radicals. This treatment is inadequate for more than the simplest cases, which are apparently all that the authors have intended should be included. Chapters XVI and XVII take up the analysis of dry unknowns and appear to be only moderately well done.

In the cases of several of the cations with which the student frequently has difficulty several good tests are given, *e. g.*, bismuth, arsenic, and manganese. Under the tests for manganese is included the oxidation of manganese by periodate, which so far as the reviewer knows has not previously been included in a book on elementary qualitative analysis. On the whole this book is unusually well done and should find a wide usefulness.

LYMAN J. WOOD

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CHEMICAL DISCOVERY AND INVENTION IN THE TWENTIETH CENTURY. *Sir William A. Tilden*, D.Sc., LL.D., Sc.D. F.R.S. Revised by *S. Glasstone*, D.Sc., Ph.D., F.I.C., Lecturer in Chemistry, University of Sheffield. E. P. Dutton & Company, Inc., New York City, 1936. Sixth edition, revised and reset. xvi + 492 pp. 13.6 × 21.4 cm. 12 portraits and 131 other illustrations. Price $4.00.

For nearly twenty years this book, the first edition of which appeared in 1917, has made chemistry interesting, and its accomplishments significant and comprehensible to a large public untrained in the mysteries of the science. The same public since 1917 has been offered many other works of popularization, but the present book remains one of the best of them. While one may reasonably have doubted in 1917 whether the chemical discovery and invention of the seventeen years just past were sufficiently important, sufficiently different from the chemical discovery and invention of the nineteenth century, to deserve a new and stout book about them—there can now, twenty years later, no longer be any doubt that the twentieth century deserves a book for itself. A revolution has occurred in physics; new foundations, laid largely since 1900, have been accepted and a new structure of chemistry has been erected upon them; new products of organic synthesis have come into common use; vitamins and hormones are discussed in the daily newspapers. The book treats both of the theoretical background and of the practical achievements of contemporary chemistry.

The book is divided into four sections. The first deals with chemical laboratories and the work which is done in them; the second with modern discoveries and theories, the principles of chemistry, the electric discharge in gases, the elements of the chemist, the discovery and properties of radium, the structure and disintegration of atoms, solutions, electrolysis, the architecture of molecules, catalysis, and colloids; the third with modern applications of chemistry, hydrogen, oxygen, nitrogen, the metals and some of their compounds, luminosity of flames, petrol, coal tar, the production of dyes, drugs, hormones, and vitamins, perfumes and essential oils, vegetable fiber and cellulose, rubber and plastics, explosives, and the fixation of nitrogen; and the fourth part with modern progress in organic chemistry, sugars, proteins, natural colors, enzymes, etc. The treatment, as might be expected, conforms rather to British industrial practice than to American, but the differences are not important except to the

technician and, on occasion, to the teacher who wishes for perfect accuracy in his teaching. The terms by which some of the materials are designated are not the usual American ones, but the language is clear and intelligible. The book ought to be in every high-school library. It is just the book, too, to put into the hands of an intelligent person who wishes to be informed of the things that are going on in the world about him, or to examine the claim that chemistry is a dominant factor in determining the character of twentieth century civilization.

TENNEY L. DAVIS

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LABORATORY EXPERIMENTS IN PHYSIOLOGICAL CHEMISTRY. *Arthur K. Anderson*, Ph.D., Professor of Physiological Chemistry, The Pennsylvania State College. John Wiley & Sons, Inc., New York City, 1936. vii + 224 pp. 20 figs. 15 × 23 cm. $1.50.

This book is designed to serve as a laboratory manual to accompany the author's *Essentials of Physiological Chemistry*, published in 1935, and may therefore be assumed to be designed for the same group of students as the earlier book, *i. e.*, for students with a limited background of chemistry and biology. It is adapted not only to the needs of students in home economics whose interest is primarily in human nutrition, but also to the needs of those desiring a more general course in physiological chemistry, premedical students, and students in agriculture, biology, or bacteriology. The experiments are not designed for, nor are they suitable to meet the needs of medical students. With the proper selection of material, as indicated by the author, the work may be completed in six hours of laboratory work in one semester.

The questions which follow each experiment are well chosen and should stimulate reading of the companion text whose use with a manual of this type is to be assumed. The directions are clear and concise. While the reviewer sympathizes with the desire of the author to avoid anticipating the results which the student may be expected to obtain in the laboratory, he feels, nevertheless, that somewhat more detail in explanation of the conduct and purpose of the experiments is desirable. Thus, in the experiments concerned with the formation of osazones on page 62, some mention of the fact that the osazone derivatives of certain sugars form rapidly and are sufficiently insoluble to crystallize out in the boiling solution should stimulate the student to more careful observation.

An excellent feature of the book is the inclusion, wherever possible, of quantitative material rather than the older type of qualitative experiments. It is the reviewer's experience that students weary of and ultimately perform perfunctorily the long series of the older type of qualitative experiments, but carefully and enthusiastically carry out even the simpler experiments with a quantitative background. Biological chemistry has been slow to incorporate such material, particularly in the more elementary courses. Professor Anderson, realizing this need, and also the limitations in the preparation of the students for whom the book is designed, has included, to make good this lack of chemical background, a brief but well-selected series of experiments on the fundamentals of quantitative procedures.

Certain procedures which are not usually classed as chemical are included, notably, the determinations of the white and red blood cell counts. It would hardly seem important for students in the preliminary non-medical branches to be taught the difficult differential white blood cell count, whose importance and significance can hardly be understood by them. Similar criticism might be made of the inclusion of the determination of the basal metabolic rate in so elementary a course.

The book should be useful to those who must teach students without detailed preparation in chemistry and may be recommended to those who have neither the time nor the inclination to formulate their own laboratory directions.

HOWARD B. LEWIS

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SYNTHETIC INORGANIC CHEMISTRY. *Arthur A. Blanchard*, Ph.D., Professor of Inorganic Chemistry, *Joseph W. Phelan*, Ph.D., Late Professor of Inorganic Chemistry, and *Arthur R. Davis*, Ph.D., Assistant Professor of Chemistry, at the Massachusetts Institute of Technology. Fifth edition. John Wiley & Sons, Inc., New York City, 1936. xii + 385 pp. 25 figs. 15 × 23 cm. $3.00 net.

Synthetic Inorganic Chemistry is designed as "a course of laboratory and classroom study for first-year college students." It was first published in 1908. As stated in the preface to the fifth edition, "A considerable portion of the text has been wholly rewritten, and the entire text has been subjected to revision and rearrangement. Specific new exercises and discussions which have been introduced include such topics as the determinations of vapor density and molecular weight, the standardization of acids and the titration of acids and bases, Faraday's law, and the use of the pH scale of hydrogen-ion concentration. Several new preparations have been introduced, and a few of the old ones have been discontinued. A complete list of apparatus and chemicals required in the course has been added to the appendix."

The textbook is used with the large freshman class at the Massachusetts Institute of Technology, who should have met an entrance requirement in chemistry. The entire year's work for both laboratory and classroom is outlined in the book.

Pages 1–3 give Directions for Work followed by 18 pages devoted to Notes on Laboratory Manipulation. The manual contains eleven chapters entitled as follows: I. The Quantitative Aspects of Chemistry; II. Water and Solution; III. The Theory of Ionization; IV. The Non-Metallic Elements in Binary Compounds; V. Alkali and Alkaline Earth Metals; VI. Elements of Group III; VII. Heavy Metals of Groups I and II; VIII. The Oxy-Acids and Salts of the Non-Metals; IX. Elements of Group IV; X. Elements of Group V; XI. Heavy Metals of Groups VI, VII, and VIII.

There are 73 preparations in the manual, and the instructions are clear and adequate. There are also many excellent questions and problems.

The textbook also contains an extensive appendix which gives much valuable information.

Synthetic Inorganic Chemistry is a conservative book. The treatment of the theory of ionization (p. 82) is an example. The modern definitions of bases and acids are not given. The reviewer has not found much to criticize. On page 74 a *molal* solution is defined as follows: "A molal solution contains one mole of dissolved substance in 1 liter of solution, *e.g.*, 40 grams of NaOH or 98 grams of H_2SO_4." This is pretty generally given as the definition of a molar solution, while a molal solution is defined as one containing 1 mole in 1000 grams of water. On page 354 one finds the following statement: "The nuclei of all elements consist of closely packed aggregates of protons and electrons." It is now considered likely that nuclei are built of protons and *neutrons*. The total mass of the nucleus can be accounted for by assuming that the nucleus is composed of protons and neutrons.

Both authors and publishers have done their part well. *Synthetic Inorganic Chemistry* has been one of our standard manuals for many years. It is a book designed to lay a solid foundation in chemistry, and its usefulness will no doubt be much enhanced by the latest revision.

WILLIAM FOSTER

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PRINCETON, N. J.

EDUCATIONAL, PSYCHOLOGICAL, AND PERSONALITY TESTS OF 1933, 1934, AND 1935. *Oscar K. Buros*, Rutgers University. Published by the School of Education, Rutgers University, 1936. 83 pp. 15 × 23 cm. Paper-bound, $0.50.

Descriptive bibliography; 503 titles. The pamphlet includes an introduction, key to classification, publishers' directory and index, and author and title indices.

ANNUAL INDEX—JOURNAL OF CHEMICAL EDUCATION

Volume 13, 1936

The annual index for volume 13 of the JOURNAL OF CHEMICAL EDUCATION is divided into two parts—an Author Index and a Subject Index, each alphabetically arranged. Letters (Ar), (Ab), (B), (C), (E), (F), and (P) have been used after the various items to designate, respectively: article, abstract, book review, correspondence, editorial, frontispiece, and portrait or picture.

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